APPENDIX I

GLOSSARY

ABSOLUTE ZERO —The point where all molecular motion ceases, -460°F.

AC — Alternating current.

AEROBIC DECOMPOSITION — Bacterial decomposition that occurs in the presence of oxygen.

AFTERCOOLER — Device which cools the final discharge from a compressor.

ANGLE VALVE — A stop valve that is actually a combination valve and elbow since its outlet branch is at right angles to its inlet branch.

ASME — American Society of Mechanical Engineers.

BILL OF MATERIAL — A list of all materials required to complete an installation based on takeoffs and estimates.

BOILER — An enclosed vessel that converts water to steam of proper temperature and pressure for an intended purpose.

BOILER SETTING — The structure that encloses a boiler and forms a furnace.

BREECHING — Connects a boiler to the stack.

BUSHING — A plumbing fitting used to reduce the pipe from one size to another size.

BUTTERFLY VALVE — A two-position valve with a vertical or horizontal disk.

CAP — A plumbing fitting used to close off a length of pipe.

CATHODIC PROTECTION — The use of material and liquid to cause electricity to flow to avoid corrosion.

CBMU — Construction Battalion Maintenance Unit.

CBR — Chemical, Biological, and Radiological.

CBU — Construction Battalion Unit.

CEC — Civil Engineer Corps.

CENTRIFUGAL FORCE — The force that impels a substance to move outward from the center of rotation.

CENTIGRADE — A thermometric scale in which 0 degrees represents the freezing point and 100 degrees represents the boiling point of water at a pressure of 1 atmosphere. Generally used with metric units of measure. Equal to the international thermometric scale of Celsius.

CHECK VALVE — An automatic non-return valve or a valve which permits a fluid to pass in one direction but automatically closes if the fluid begins to pass in the opposite direction.

CLARIFICATION OF WATER — The removal of suspended materials to produce a clear, clean liquid.

COLIFORM — The coliform groups of organisms are a bacterial indicator of contamination. This group has as one of its primary habitats, the intestinal tract of human beings. Coliforms also may be found in the intestinal tract of warm-blooded animals and in plants, soil, air, and the aquatic environment.

COMSECONDNCB — Commander, Second Naval Construction Brigade.

COMTHIRDNCB — Commander, Third Naval Construction Brigade.

COMPRESSOR — Pump of a refrigerating mechanism which draws a low pressure on the cooling side of the refrigerant cycle and squeezes or compresses the gas into the high pressure or condensing side of the cycle.

CONDENSATION — The process of changing a vapor to a liquid.

CONDENSER — Component in a refrigeration system that removes and dissipates heat from a compressed refrigerant.

CONDUCTION — The transmitting of heat from one substance or part to another substance or part that are in direct contact with each other.

CONVECTION — The transfer of heat by means of a medium, such as water, air, and steam.

COUPLING — A plumbing fitting used to join two lengths of pipe in a straight run.

DEGREE OF TEMPERATURE — Measurement of heat intensity.

DEHYDRATOR — Device used to remove moisture from a refrigerant system.

DEW POINT — Temperature at which vapor (at 100 percent humidity) begins to condense and deposit as a liquid.

DIATOMACEOUS EARTH — A porous mineral powder, used as a filtering medium for the removal of suspended materials.

ELBOW — A plumbing fitting used to change the direction of a length of pipe at 90° and 45° angles.

EVAPORATOR — Component of a refrigeration system that permits the absorption of heat from a desired medium or space.

EVAPORATION — A process of converting a liquid, by heat, into a vapor or gas.

FILTER-DRIER — Device for removing small foreign particles and moisture from refrigerant fluid.

FITTINGS — Devices which when placed in a pipe system make branch connections or changes in a direction of a line.

GATE VALVE — A sluice with two inclined seats between which the valve wedges down in closing. The passage through the valve is in an uninterrupted line, and when the valve is opened, the sluice is drawn up into a dome or recess, leaving an unobstructed passage the full diameter of the pipe.

GLOBE VALVE — A valve with a round, ball-like shell that is used for regulating or controlling the flow of gases or steam.

GPD — Gallons per day.

GPH — Gallons per hour.

GPM — Gallons per minute.

HEAT — The energy that is measured in British thermal units.

HERMETICALLY SEALED — Caused to be airtight.

HUMIDITY — The amount of water vapor in a given volume of air.

HYDROLOGIC CYCLE — Process by which water is circulated from ocean to atmosphere to earth's surface.

ID — Inside diameter.

INFLUENT — Water flow into a sewage or water treatment plant or equipment.

JOINING — All the procedures used to connect pipes together.

LATENT HEAT — Amount of heat required to change the state of a substance without a measurable change in temperature.

MATERIAL TAKEOFF — The estimate of materials required for a job based on plans and specifications.

METERING DEVICE — Valve or device used to regulate amount and state of refrigerant as it passes through the system.

NAVFAC — Naval Facilities Engineering Command.

NCR — Naval Construction Regiment.

NCTC — Naval Construction Training Center.

NMCB — Naval Mobile Construction Battalion.

OD — Outside diameter.

PACKING — Materials used to seal moving machinery joints against leakage.

P H — A value used to measure the acidity or alkalinity (basic) of a substance. A pH scale is from 0 to 14, with 7.0 as neutral. Below 7.0 on the scale is acid, and above 7.0 on the scale is alkaline or basic. Used in water treatment and purification.

PLUG — A plumbing fitting used to close off a fitting or a length of pipe by screwing into the fitting or pipe.

PPM — Parts per million.

PSI — Pounds per square inch.

PSIG — Pounds per square inch gauge.

PUMP — A mechanical device which applies a force to move any substance that flows or can be made to flow.

RADIATION — The transfer of heat through space by heat waves.

RECEIVER — Device in a refrigeration system to store refrigerant used by the system.

REDUCING VALVE — A spring-loaded or lever-loaded valve similar to a safety valve, designed to maintain a lower end constant pressure beyond the valve.

RELATIVE HUMIDITY — The percentage of water vapor in the air when compared to the amount it does hold as to the amount it could hold.

REVERSE OSMOSIS — A process whereby a solution flows through a semipermeable membrane into an area of lower solute concentration.

ROICC — Resident Officer- in-Charge of Construction.

ROUGHING IN — The installation of all parts of a plumbing system; completed before installation of fixtures.

SENSIBLE HEAT — Heat that can be measured in degrees of temperature with a thermometer.

SPECIFIC HEAT — The quantity of heat expressed in Btu required to raise 1 pound of any substance 1°F in temperature.

SUPERHEAT — The amount of heat expressed in Btu added to a substance above its boiling temperature.

TOTAL HEAT — Sensible heat plus latent heat expressed in Btu.

TRAMAN — Training manual.

VALVE — A device for regulating, stopping, or starting flow in a system and for controlling direction of flow.

VACUUM — Pressure lower than atmospheric pressure.

VAPORAZATION — The process of changing a liquid to a vapor.

VELOCIMETER — Instrument that measures air speeds using a direct-reading air speed indicating scales.

GLOSSARY OF

CHEMICALS USED IN WATER TREATMENT

ALUMINUM HYDROXIDE — AIOH, Reagent, used to decolorize water samples when preforming chloride tests on water.

ALUMINUM SULFATE — (Alum), $A1_3(SO_4)_3$, a white salt, a coagulant, used to flocculate dissolved solids in a weak acid water environment.

AMMONIA — NH_3, an alkaline colorless gas, used in solution to detect leaks in chlorine equipment and systems.

BARIUM CHLORIDE — $BaC1_2$, Reagent, used to test for sulfates in water.

CALCIUM HYPOCHLORITE — $CaC1_2O_2$, a granular white powder used to disinfect water.

CARBON DIOXIDE — CO_2, a liquid, is used to lower pH of softened and settled potable water.

CHLORINE — $C1_2$, a natural chemical element (Cl). A powerful disinfectant, used extensively in water treatment. As a gas, it's color is greenish yellow, and it is 2 1/2 times heavier than air. As a liquid, it's color is amber, and it is about 1 1/2 times heavier than water. It is an oxidizer, and is toxic to all organisms and corrosive (in the presence of water) to most metals.

DIAMINETETRACETATE — (EDTA), Reagent, used in solution with Sodium Ethylene to detect minerals which cause hardness in water.

FERRIC CHLORIDE — $FeC1_3$, a dark salt that hydrates to a yellow-orange form. A coagulant, used to flocculate dissolved solids in a strong acid water environment.

FERRIC SULFATE — FeS_3, a coagulant, used to flocculate dissolved solids in a strong acid water environment.

FERROUS SULFATE — $FeSO_4$, a coagulant, used to flocculate dissolved solids in a strong base (alkaline), water environment.

HYDRATED LIME — (Caustic Lime) $CaOH_2$, a dry white powder, a strong base (alkaline), consists of calcium hydroxide made by treating caustic lime with water. Used to balance water pH and absorb chlorine.

METHYL ORANGE — Reagent, used in solution to determine the alkalinity of water.

METHYL PURPLE — Reagent, used in solution to determine the alkalinity of water

PHENOLPHTHALEIN — $C_{20}H_{14}O_4$, Reagent, used as an pH indicator for water testing. Red color in bases (alkalines) or decolorized in an acid.

POTASSIUM CHROMATE — KC1, Reagent, used in testing for chlorine levels in water.

POTASSIUM HYDROXIDE-(Caustic Potash) K_2CrO_7, a white powder, strongly basic (alkaline), when dissolved in water produces heat. Used to balance water pH and absorb chlorine. Also used as a reagent to test water salinity.

SILVER NITRATE — $AgNO_3$, Reagent, used to determine amount of salinity and chloride in water.

SODIUM CARBONATE — (Soda ash), Na_2CO_3, salt of carbonic acid, strongly basic (alkaline). Used in

water softening, and balancing water pH to aid coagulation.

SODIUM ETHYLENE — (EDTA), $Na_2CH_3CH_2$, Reagent, used in solution with Diaminetetracetate, to detect minerals which cause hardness in water.

SODIUM HYDROXIDE — (Caustic Soda) NaOH, a strong base (alkaline), white powder used to balance pH in water to aid coagulation, and absorb chlorine.

SODIUM HYPOCHLORITE — NaOC1, a salt usually furnished in solution, used for disinfection of water.

SULFURIC ACID — (Standard), H_2SO_4, strong acid, used to balance water pH and aid in coagulation.

THIOSULFATE — A salt, used to neutralize chlorine water. Used to sterilize water sample containers.

APPENDIX II

TABLES FOR MAINTENANCE PROCEDURES

Table A

Permissible Enlargement and Ellipticity of Holes in Tube Sheets

Outside diameter of tube (inches)	Maximum tube hole diameter (Inches)	Maximum ellipticity (inches)
1	1 1/16	1/32
1 1/4	1 5/16	1/32
1 1/2	1 37/64	3/64
1 3/4	1 53/64	3/64
2	2 3/32	1/16
2 1/4	2 11/32	1/16
2 1/2	2 5/8	5/64
3	3 1/8	5/64
3 1/4	3 13/32	3/32
3 1/2	3 21/32	3/32
4	4 3/16	1/8
4 1/2	4 11/16	1/8

Table B

Preoperating Checks for Boilers

Equipment	Check/Action
Boiler room	Remove rags, paint cans, oil spots from deck Stow tools and equipment
Furnace/gas passages	Must be clean and clear and all doors must fit tight Must be in good repair No oil/tools in combustion chamber Must be purged
Valves	Good operating condition Bent stems Missing/broken handwheels
Piping	Inspect piping for leaks Check for proper support
Electrical systems	Oil-soaked or frayed wiring Damaged or loose conduit Improperly secured control boxes
Guards	Tight and in proper position
Water-gauge glass	Well lighted Not stained

Table C

Additional Preoperating Checks for Gas-fired Boilers

Equipment	Checks
Pilot & main gas cock	Operate smoothly
Copper tubing	No restrictions, such as kinks or flat spots
Air shutters	Operate freely Linkage must not have too much lost motion
Burner & main gas valve	Must be firmly supported
Boiler Room	No free gas. Ventilate if present and test all piping with soap solution

Table D

Additional Preoperating Checks for Oil-fired Boilers

Equipment	Checks
Strainers	Inspect & clean
Burners	Must be clean Nozzle must be clean Inspect and set electrodes Check all fittings for leaks Check operation of burner safety switch
Oil system	Inspect for leaks, and repair

Table E

Operational Checks for Boilers

EQUIPMENT	ACTION/CHECK
Water Level	–Check frequently as water expands during the heating up period.
Main steam stop bypass (if installed)	–Open if the boiler is to be cut in on a cold line; –Main steam stop can be opened when there is no other boiler on the same steam line.
Air cock	–Close after steam has formed and has blown all air from boiler.
Steam pressure	–Raise slowly, usually 1/2 to 2 1/2 hours, depending upon type, size and condition of boiler. –Temperature of water should be raised at a rate of 100°F per hour.
Safety valve	– Manually lifts when pressure is at least 75% of the valve setting –Make sure valves reseat properly; if valves fail to reseat, lift them a second time.
Boiler feedwater	–Commence feeding boiler, it probably will be automatically controlled.
Firing	–Gas; Maintain ignition; maintain air-fuel ratio; there should be no soot formation. –Oil; Maintain ignition, observe flame and adjust dampers; check accuracy by flue-gas analysis.
Water level	–Blow down gauge glass and water column (observe promptness of return of water in glass). –Keep at proper level. –Frequently, determine true level of water with different methods.
Boiler blowdown	–Watch and monitor gauge glass. –Frequency depends on water tests.
Cutting in boiler	–If closed, open main steam stop valve slowly.

Table F

Boiler Emergencies

EMERGENCY	TASK	KEY POINTS
EMERGENCY ONE: Low water condition indicated by no water level in the gauge glass.	Secure the boiler, secure electrical switches, steam stop, and feedwater stop. Prove water level by opening try cocks. Cool the boiler slowly until the water temperature is 200°F. Secure all sources of draft. Check controls. Find out the cause for low water level. Correct the trouble. After correction has been made, add water to obtain the correct water level.	DO NOT ADD WATER TO THE BOILER to raise the water level in the gauge glass column. STAY AWAY from the discharge. DON'T FORCE COOL.
EMERGENCY TWO: High water condition indicated by gauge glass full of water.	Prove water level by opening the try cocks. Blowdown the boiler by opening the blowdown valves. Find out the cause of high water condition. Check feedwater pump controls. Correct the trouble. Secure the boiler if pump controls operate improperly.	STAY AWAY from discharge. Check blowdown pit. Watch the gauge glass until normal level is reached. If control operates properly, continue to operate the boiler.
EMERGENCY THREE: Serious tube failure making it impossible to maintain water level.	Secure the boiler by securing the electrical steam and fired systems. Add water to the boiler until the ruptured tube level is reached and the boiler is cooled to a temperature of 200°F. Open the boiler to replace the tube.	For large boilers: Water should be fed to the boiler until properly cooled. Mark the gauge glass if within its range. Observe level by whatever means available.
EMERGENCY FOUR: Flareback caused by an explosion within the combustion chamber.	Secure the boiler. Find the cause of flareback and correct the trouble. Check for sufficient fuel and type of fuel contamination. Check the burner.	Ensure that a slug of water did not interrupt flame with a refire before prepurge.
EMERGENCY FIVE: Minor tube failure indicated by trouble maintaining water level under normal steam demand.	Secure the boiler if it is possible to remove it from the line for sufficient time to make necessary repairs. Secure electrical switches. Open the steam stop and feed stop if additional water is not needed to protect remaining tubes.	If unable to secure boiler because of steaming requirements and you can maintain the water level, continue to operate. If unable to maintain the water level and/or supply, secure the boiler.
EMERGENCY SIX: Broken gauge glass on water column.	Securetop and bottomvalves. Replace gauge glass Use chains or whatever method available to prevent injury to personnel.	Boiler may be kept on line, if necessary. Check the boiler water level by using the try cocks.

Table G

Fuel Gases

Fuel	Source	Heating value Maximum (Btu per cuft)	Remarks
Natural gas	Gas wells	700–1,300 average 1,000	Ideal fuel. It is pumped to point of use
Manufactured Gas			
Carbureted Water Gas	Manufactured from coal enriched with oil vapors	520–540	A costly good fuel that is part of most city gas
Oil Gas	Manufactured from petroleum	520–540	Used on U.S. west coast; is often mixed with coke oven gas
Producer Gas	Manufactured from coal, coke, wood, etc.	135–165	Requires cleaning
Liquefied Petroleum Gas			
Propane	By-product of gasoline	2,500	Boiling point: -44°F. Liquefies under slight pressure
Butane	By-product of gasoline	3,200–3,260	Boiling point 32°F. Liquefies under slight pressure

Table H

A Comparison of Fuel Oils

Grade Number	Approximate weight/gallon	Heating value (Btu per gallon)	Type Fuel
1	6.92	136,000	A volatile distillate oil for use in burners that prepare fuel for burning solely by vaporization.
2	7.08	138,500	A moderately volatile distillate oil for use in burners which prepare fuel for burning by a combination of vaporization and atomization
4	7.58	145,000	A residual oil for burner installations not equipped with preheaters
5 (Light)	7.83	148,500	A residual oil of intermediate viscosity for use in burners equipped with preheaters; however, preheating may or may not be required depending on climate and equipment
5 (Heavy)	Greater than 5 light	Greater than 5 light	A residual oil of greater viscosity than 5 light. Preheating may be required before burning this oil; and in cold climates, preheating may be required before handling as well
6	8.16	152,000	A residual oil of high viscosity for which preheating is always required

Table I

Troubleshooting Chart for Pot and Sleeve Oil Burners

Problem	Probable Cause	Possible Remedy
Burner Smokes	Improper fuel	Use recommended fuel
	Insufficient oil flow Excessive chimney draft Pilot casing is poorly fitted Dirty burner	Troubleshoot for low flow Check draft regulator Remove and install correctly Clean the burner
Burner goes out	Low oil supply Plugged vent on the out supply line Insufficient oil flow Improper fuel Fuel inlet plugged with carbon Dirt in the oil control valve Oil valve is not level Filter cartridge plugged Excessive chimney draft Excessive flue downdraft	Add oil if necessary Clean the vent Troubleshoot for low oil flow Use recommended fuel Clean Clean the valve Level the valve Clean the filter Check draft regulator Install downdraft hood
Burner Flooded	Dirty float valve Improper operation Needle valve stuck	Remove and clean the float valve Instruct operating personnel on proper procedures Clean or replace the valve
	Dirty burner	Clean the burner
	Excessive flue downdraft	Install downdraft hood
Low oil flow	Air trapped in oil supply line	Eliminate high points in the piping and bleed air out
	Oil control valve not level	Level the valve
	Oil may be too heavy	Only use manufacturer's recommended grade of oil
	Dirt in the supply line or in the metering mechanism	Clean the line and components
	C logged oil strainer	Clean the strainer
	Flue inlet clogged with carbon	Remove the carbon
High fuel consumption	Improper fuel	Use manufacturer's recommended grade of oil
	Heat loss	Reduce air supply to the burner
	Excessive chimney draft	Check the draft regulator
	Heat exchanger caked with slag	Clean the affected areas

Table J

Troubleshooting Chart for Gas-fired Space Heaters

Problem	Probable Cause	Possible Remedy
Motor does not run	Incorrect current	Check and correct
	Faulty wiring	Rewire properly
	Defective wiring	Replace and lubricate
Motor runs intermittently	Thermal overload protectors cutting out	If no external cause, such as improper current, can be found, replace the motor
Excessive fan and motor noise	Bent fan blade	Straighten by hand or replace if serious
	Excessive end play in shaft	If end play exceeds 1/32 inch, repair or replace
Solenoid valve hums or flutters	Installed backwards	Check arrow on valve body and correct if required
	Poor electrical connection or faulty solenoid	Check, correct, or replace
Burner does not ignite	Faulty pilot burner, thermo-couple, or thermal bulb	Check, correct, or replace
	Inoperable solenoid valve	Impart current across the leads of the valve. A click indicates satisfactory operation. Replace solenoid if necessary
Delay in main burner operations (2 to 3 min) after fan starts	Malfunctioning limit switch	Replace limit switch
Improper burning of main burner	Primary air incorrectly set	Adjust primary air after the unit has been burning for 10 to 15 minutes. Adjust the shutter down until a yellow tip appears on the flame, and then open the shutter until the yellow tip disappears.
	Incorrect orifice size	Check manufacturer's specifications for the correct size and replace.
	Incorrect gas pressure	Check manufacturer's specifications regarding correct pressure for the gas being used. Measure pressure and adjust pressure regulator to correct condition.
Pilot fails to light or will not stay lit	Stopped pilot line	Clean line or replace, if required
	Excessive draft	Eliminate draft
	Low gas pressure	Check pressure regulator or tank level, if LPG

Table K

Oil Burner Troubleshooting

Burner fails to start

Source	Procedure	Causes	Correction
Thermostat control	Check thermostat settings	Thermostat is in OFF or COOL position	Switch to HEAT
		Thermostat is set too low	Turn to higher
Safety overloads	Check burner motor, primary safety control, and auxiliary limit switch	Burner motor overload tripped	Push motor overload reset button
		Primary control tripped on safety	Reset safety switch lever
		Auxiliary limit switch tripped on safety	Push auxiliary limit switch reset button
Power	Check furnace disconnect switch and main disconnect switch	Switch open Blown fuse or tripped breaker	Close switch Replace fuse or reset breaker
Thermostat unit	Touch jumper wire across thermostat terminals on primary control. If burner starts, then fault is in thermostat circuit	Loose thermostat screw connections Dirty contacts Thermostat not level Faulty thermostat	Tighten connection Clean contacts Level thermostat Replace thermostat
Cad Cell	Disconnect flame detector wires at primary control. If burner starts, fault is in the detector circuit	Flame detector leads shorted	Separate leads
		Flame detector exposed to light	Seal off false source of light
		Short circuit in flame detector	Replace detector

Table K

Oil Burner Troubleshooting (Continued)

Burner fails to start

Source	Procedure	Causes	Correction
Primary Control (1)	Place trouble light between the black and white leads. No light indicates there is no power to the control.	Primary or auxiliary control switch open	Check dial adjustment. Set to maximum stop setting Jumper terminals; if burner start switch is faulty, replace control.
		Open circuit between disconnect switch and limit control	Trace wiring and repair or replace
		Low line voltage or power failure	Call power company
Primary Control (2)	Place trouble light between the orange and black leads. No light indicates the control is faulty.	Defective internal control circuit	Replace control
Burner (1)	Place trouble light between the black and white leads to burner motor. No light indicates no power to the burner motor.	Blown fuse	Replace fuse
Burner (2)	Place trouble light between the black and white leads to burner motor. Light indicates power to the motor and a burner fault.	Binding burner blower wheel	Turn off power and rotate blower wheel by hand.
		Seized fuel pump	If seized, free wheel from binding or replace fuel pump.
		Defective burner motor	Replace motor

Table K

Oil Burner Troubleshooting (Continued)

Burner starts but no flame is established

Source	Procedure	Causes	Correction
Oil supply	Check tank gauge or use dip stick Coat dipstick with litmus paper and insert to bottom of the tank. Listen for pump whine	No oil in tank Water in oil tank Tank shutoff valve closed	Fill tank Pump or drain the water out if greater than 1 inch in depth Open valve
Oil filters and oil line	Listen for pump whine Open bleed valve or gauge port. Start burner. No oil or milky oil indicates loss of prime	Oil line filter plugged Kinks or restriction in oil line Plugged fuel pump strainer Air leak in oil supply line	Replace filter cartridge Repair or replace oil line Clean strainer or replace pump Locate and correct leak and tighten all connections
Oil Pump	Install pressure gauge on pump and read pressure. Pressure should not be less than 100 psig	Pump partially or corn- pletely frozen – No pressure and motor locks out on overload Coupling disengaged or broken – no pressure. Fuel pressure too low.	Replace pump Reengage or replace coupling Adjust pressure to 100 psig
Nozzle	Disconnect ignition leads. Observe oil spray (gun assembly must be removed form the unit) Inspect nozzle for plugged orifice or carbon buildup around orifice	Nozzle orifice plugged Nozzle strainer plugged Poor or off center spray	Replace nozzle with same size, spray angle, and spray type
Ignition electrodes	Remove gun assembly and inspect electrodes and leads.	Fouled or shorted electrodes and leads; Eroded electrode tips Improper position of electrode tips Bad buss bar connection Cracked or chipped insulators Cracked or burned lead insulators	Clean electrodes and leads Dress up electrode tips and reset gap to 1/8 inch and correctly position the tips Retension and align Replace electrode Replace electrode leads
Ignition Trans- former	Connect ignition leads to transformer. Start burner and observe spark. Check line voltage to transformer primary	Low line voltage Burned out transformer windings No spark or weak spark	Check voltage at power source. Correct cause of voltage drop or call power company. Replace transformer Properly ground transformer case
Burner Motor	Motor does not come up to speed and trips out on overload. Turn off power and rotate blower wheel by hand to check for binding or excessive drag	Low line voltage Pump or blower overloading motor Faulty motor	Check voltage at power source. Correct cause of voltage drop or call power company Correct cause of overloading or replace motor Replace motor

Table K

Oil Burner Troubleshooting (Continued)

Burner starts and fires but locks out on safety

Source	Procedure (1)	Procedure (2)	Cause	Correction
Poor fire	After burner fires, immediately place jumper across flame detector terminals at primary control	If burner continues to run, fault may be due to poor fire. Inspect fire.	Unbalanced fire	Replace nozzle
			Too much air – lean short fire	Reduce combustion air – check combustion
			Too little fire – long dirty fire	Increase combustion air – check combustion
			Excessive draft	Adjust barometric damper for correct draft
			Too little draft or Restriction	Correct draft or remove restriction
Flame detector		If fire is good, fault is in flame detector. Check detector circuit.	Dirty cad cell face	Clean cad cell face
			Faulty cad cell – exceeds 1,500 ohms	Replacecadcell
			Loose or defective cad cell wires	Secure connections Or replace cad cell holder and wire leads
Primary control		If burner locks out on safety, fault is in primary control.	Primary control circuit defective	Replace primary control

Table K

Oil Burner Troubleshooting (Continued)

Burner starts and fires but locks out on safety

Source	Procedure (1)	Procedure (2)	Cause	Correction
Poor fire	After burner fires, immediately place jumper across flame detector terminals at primary control	If burner continues to run (does not lock out on safety), fault may be due to poor fire. Inspect fire.	Unbalanced fire Too much air – lean short fire	Replace nozzle Reduce combustion air – check combustion
			Too little fire – long dirty fire	Increase combustion air – check combustion
			Excessive draft	Adjust barometric damper for correct draft
			Too little draft or restriction	Correct draft or remove restriction
Flame detector		If fire is good, fault is in flame detector. Check detector circuit.	Dirty cad cell face	Clean cad cell face
			Faulty cad cell –exceeds 1,500 ohms	Replace cad cell
			Loose or defective cad cell wires	Secure connections Or replace cad cell holder and wire leads
Oil supply (Listen for pump whine)		If burner looses flame (does not lock out on safety), fault is in fuel system.	Air slug or leak in supply line	Check supply line and oil tank
			Restriction or plugged strainers	Remove restriction or replace pump

Table K

Oil Burner Troubleshooting (Continued)

Burner runs continuously (too little heat)

Source	Procedure (1)	Procedure (1)	Cause	Correction
Combustion	Check burner combustion for CO2 stack temperature and smoke	If burner continues to run (does not lock out on safety), fault may be due to poor fire Inspect fire.	Unbalanced fire Too much air – lean short fire	Replace nozzle Reduce combustion air – check combustion
			Too little fire – long dirty fire	Increase combustion air – check combustion
			Excessive draft	Adjust barometric damper for correct draft
			Too little draft or restriction	Correct draft or remove restriction
Flame detector		If fire is good, fault is in flame detector. Check detector circuit.	Dirty cad cell face	Clean cad cell face
			Faulty cad cell – exceeds 1,500 ohms	Replacecadcell
			Loose or defective cad cell wires	Secure connections Or replace cad cell holder and wire leads
Oil supply (Listen for pump whine)		If burner looses flame (does not lock out on safety), fault is in fuel system.	Air slug or leak in supply line	Check supply line and oil tank
			Restriction or plugged strainers	Remove restriction or replace pump

Table K

Oil Burner Troubleshooting (Continued)

Burner starts and fires but short cycles (too little heat)

Source	Procedure	Causes	Correction
Thermostat	Check thermosta	Heat anticipator set too low	Correct heat anticipator setting
		Vibration in thermostat	Correct source of vibration
		Thermostat in warm-air draft	Shield thermostat from draft or relocate thermostat
Limit Control	Connect voltmeter between line voltage connections to primary control (black and White leads). If burner cycles due to power interruption, it is cycling off limit.	Dirty air filters (furnace)	Clean or replace filter
		Blower running too slow	Speed up blower for 85 to 95 temperature rise
		Blower motor seized or burned out	Replace motor
		Blower bearings seized	Replace bearings and shaft
		Blower wheel dirty	Clean blower wheel
		Blower wheel in back-wards	Reverse blower wheel
Power	If voltage fluctuates, then fault is in power source. Recheck voltage at power source	Wrong motor rotation	Replace with motor of correct rotation
	Disconnect thermostat wires at primary control.	Restrictions in return air or supply air system	Correct cause of restric-tion
	1. If burner turns off, fault is in thermostat circuit	Adjustable limit control set too low	Reset limit to maximum stop setting
	2. If burner does not turn off, fault is in the primary control..	Loose wiring connection	Locate and secure connec- tion
		Low or fluctuating line voltage	Call power company

Table K

Oil Burner Troubleshooting (Continued)

Burner starts and fires but locks out on safety

Source	Procedure (1)	Procedure (2)	Cause	Correction
Poor fire	After burner fires, immediately place jumper across flame detector terminals at primary control	If burner continues to run, fault may be due to poor fire. Inspect fire.	Unbalanced fire Too much air – lean short fire	Replace nozzle Reduce combustion air – check combustion
			Too little fire – long dirty fire	Increase combustion air – check combustion
			Excessive draft	Adjust barometric damper for correct draft
			Too little draft or Restriction	Correct draft or remove restriction
Flame detector		If fire is good, fault is in flame detector. Check detector circuit.	Dirty cad cell face Faulty cad cell –exceeds 1,500 ohms Loose or defective cad cell wires	Clean cad cell face Replace cad cell Secure connections Or replace cad cell holder and wire leads
			Primary control circuit defective	Replace primary control
Primary control		If burner locks out on safety, fault is in primary control.		

Table K

Oil Burner Troubleshooting (Continued)

Burner runs continuously (too much heat)

Source	Procedure	Cause	Correction
Thermostat	Disconnect thermostat wires at primary control	Shorted or welded thermostat contacts	Repair or replace thermostat
	1. If burner turns off, fault is in the thermostat circuit.	Stuck thermostat bimetal	Clear obstruction or replace thermostat
		Thermostat not level	Level thermostat
		Shorted thermostat wires	Repair short or replace wires
		Thermostat out of calibration	Replace thermostat
		Thermostat in cold draft	Correct cause of draft or relocate thermostat
	2. If burner does not turn off, the fault is in the primary control.	Defective primary control	Replace primary control

Table L

Common Operating Difficulties for Oil Burners

Condition	Check for
Furnace pulsates on starting, stopping, or during operation.	Proper adjustment of the nozzle electrode assembly land blast tube in relation to each other and firebox. Improper draft. Ensure no downdraft. Leaks in chimney. Defective nozzle. Air in the line, between fuel unit and nozzle.
Flame is raw and stingy.	Too large an opening in the air adjustment. Partly plugged nozzle. Air in the pump.
Ignition points collect carbon.	Ignition points too close to nozzle. Nozzle loose in holder. Improper oil cutoff when burner is shutdown.
Oil pump is noisy.	Air in oil line. Leaks in suction line. Plugged strainer.
Burner starts and stops too frequently.	Thermostat is improperly wired. Thermostat is improperly adjusted. Drive arm adjustment is incorrect. Limit control is set too low. Plugged air filters. Nozzle is too large for unit.
Burner failsafe is activated.	Low voltage occurring at night. Incorrect polarity of wiring. Primary control or stack switch improperly adjusted.
No oil at the nozzle	Fuel too low in the supply tank. Plugged nozzle. Leak in the suction line. Leak in the vacuum-gauge port. Pump failing to turn. Leaking strainer gasket. Leaking pump-shaft seal. Fuel unit not operating.

Table M

Oil Pump Troubleshooting

CONDITION	CAUSE	REMEDY
NO OIL FLOW AT NOZZLE	Oil level below intake line in supply tank	Fill tank with oil.
	Clogged strainer or filter	Remove and clean strainer. Replace filter element.
	Clogged nozzle	Replace nozzle.
	Air leak in intake line	Tighten all fittings in intake line. Tighten unused intake port plug. Check filter cover and gasket.
	Restricted intake line (High-vacuum reading)	Replace any kinked tubing and check any valves in intake line
	A two-pipe system that becomes air bound	Check for and insert bypass plug. Make sure return line is below oil level in tank.
	A single-pipe system that becomes air bound	Loosen gauge port plug or easy flow valve and bleed oil for 15 seconds after foam is gone in bleed hose. Check intake line fitting for tightness. Check all pump plugs for tightness.
	Slipping or broken coupling	Tighten or replace coupling.
	Frozen pump shaft	Replace pump.
OIL LEAK	Loose plugs or fittings	Dope with good quality thread sealer. Retighten.
	Leak at pressure adj. Screw or nozzle plug	Washer may be damaged. Replace the washer or O-ring.
	Blown seal (single-pipe system)	Check to see if bypass plug has been left in unit. Replace oil pump.
	Blown seal (two-pipe system)	Check for kinked tubing or other obstructions in return line. Replace oil pump.
	Seal leaking	Replace oil pump.
	Cover	Tighten cover screws or replace damaged gasket.
NOISY OPERATION	Bad coupling alignment	Loosen fuel unit mounting screws slightly and shift fuel unit in different positions until noise is eliminated. Retighten mounting screws.
	Air in inlet line	Check all connections. Use only good flare fittings.
	Tank hum on two-pipe system and inside tank	Install return line hum eliminator in return line.
PULSATING PRESSURE	Partially clogged strainer or filter	Remove and clean strainer. Replace filter element.
	Air leak in intake line	Tighten all fittings.
	Air leaking around cover	Be sue strainer cover screws are tightened securely. Check for damaged cover gasket.
IMPROPER NOZZLE CUT-OFF	To determine the cause of improper cutoff, insert a pressure gauge in the nozzle port of the fuel unit. After a minute of operation, shut burner down. If the pressure drops from normal operating pressure and stabilizes, the fuel unit is operating properly and air is the cause of improper cutoff. If, however, the pressure drops below 80 psig, oil pump should be replaced.	
	Filter leaks	Check face of cover and gasket for damage.
	Strainer cover loose	Tighten four screws on cover.
	Air pocket between cutoff valve and nozzle	Run burner, stopping and starting unit, until smoke and after-fire disappears
	Air leak in intake line	Tighten intake fittings. Tighten unused intake port and return plug.
	Partially clogged nozzle strainer	Clean strainer or change nozzle.
	Leak at nozzle adapter	Change nozzle and adapter.

Table N

Troubleshooting Chart for Thermostats

PROBLEM	PROBABLE CAUSE	POSSIBLE REMEDY
Thermostat fails to energize heating system	Setting too low	Check and increase setting.
	Wired incorrectly	Correct wiring.
	Loose or broken wiring	Replace or repair wiring
	Loose unit or mounting plate	Level and tighten mounting screws
	Dirty contacts	Clean contacts
	Affected by warm draft	Relocate.
	Mercury tube broken	Replace thermostat.
	Improper type for job	Replace with proper type.
Thermostat fails to de-energize heating system	Setting too high	Check and decrease setting
	Affected by cool draft	Relocate.
	Improper type for job	Replace with proper type
	Wired incorrectly	Correct wiring.
	Contacts fused together	Replace unit.
	Not level (mercury switch type)	Level and tighten mounting screws.
	Wiring shorted	Locate short and repair.
Room temperature does not reach thermostat setting or else exceeds the setting	Defective dial	Calibrate or replace unit.
	Improper type for job	Replace with proper type
	Thermometer reading incorrect	Replace unit.
	Defective components	Replace unit
	Heating components too small or too large for area	Check and correct if feasible.
System short-cycles	Improper type for job	Replace with proper type.
	Dirty contacts	Clean contacts.
	Incorrectly set thermostat heater	Adjust or replace.
	Heating components too large for area	Decrease output.

Table O

Troubleshooting Hot-Water Heating Systems

SYSPTOMS	REMEDY
Boiler smokes through the feed doors	Clean the boiler flues and the flue pipes. Repair any chimney leaks.
Boiler heats slowly	Increase the draft. Check on the type of fuel. Clean the boiler of scale. Blowdown the boiler.
Radiator produces insufficient heat	Clean the boiler of scale. Change to a larger boiler. Blowdown the boiler. Increase the draft, and check on the type of fuel.
Radiators do not heat	Insufficient water in the system. Bleed the air from the system. Open the radiator valves, and check the operation of the circulation.
Distribution piping does not transfer hot water to the radiators	Insufficient water in the system. Bleed the air from the high points in the distribution piping. Check the operation of the circulation pump. Check for corrosion stoppage in the distribution piping.

Table P

Inspection and Maintenance of Coppers and Other Steam-Related Equipment

INSPECTION POINT	SYMPTOMS	TIME	POSSIBLE TROUBLE/CAUSES	POSSIBLE CORRECTIONS
Steam jacket	Not heating	When noted	No steam; valve stuck closed; trap malfunctioning	Check steam supply; free stuck valve
Steam jacket	Stays hot	When noted	Valve partly open or scored seat	Repair or replace valve
Steam jacket	Leaks	Monthly	Rapid changes in temperature causing cracks; faulty weld	Raise heat slower; re-weld bust or crack
Pipe joints	Leaks	Monthly	Joint made incorrectly; not tight	Unscrew; clean and repair joint
Pipe joints	Corrosion	Monthly	Leaks or condensation	Repair and/or clean
Control valves	Stuck open or closed	When noted	No steam or too much steam; packing too tight or valve frozen	Loosen packing gland or free frozen valve steam
Control valves	Leaks at stem	Weekly	Packing not tight enough	Tighten packing
Condensate strainer	No flow	When noted	Restricted strainer	Clean strainer
Steam trap	Malfunctioning	Every 6 months	Parts worn or dirty	Disassemble, clean, and repair
Lagging	Broken or crushed	Quarterly	Water soaked; stepped on	Replace defective sections
Reducing valve	Incorrect pressure	When noted	Parts worn or dirty	Disassemble, clean, and repair; clean and adjust pressure every 6 months
Safety valve	Stuck open or lifting under pressure	When noted	Leaks or corrosion	Replace or repair valve
Covers	Tight operation	When noted	Hinges dirty	Clean and lubricate hinges
Drawoff valve	Leaks	When noted	Scored	Resurface or replace. DO NOT REPLACE WITH REGULAR GATE VALVE

Table Q

Troubleshooting for Dishwashing Machine

TROUBLE	PROBABLE CAUSE	POSSIBLE REMEDY
Dish racks slide off chain conveyor	Change of tension of either chain	Reset idler sprockets to proper tension on each chain.
Water pressure too low	Spray nozzles or slot plugged. Strainer baskets plugged. Slipped belts on pumps.	Dismantle spray assembly. Wash out all piping and clean parts. Disassemble and clean strainer. If belts are frayed or torn, replace them. Adjust tension by resetting idler pulley or by moving motor on sliding base
Water splashing on floor or into wrong compartment	Leaks around doors; torn curtains or curtains not in proper position	Realign door. Repair or replace gasket. Repair or realign curtain. Readjust spray to keep it within limits of tank.
Rinse water temperature is less than 180°F	Insufficient heat from booster heater	Remove scale from steam coil. Correct leaking fittings. Adjust gas burners. Calibrate or replace thermostat.
Spot or film on eating utensils after final rinse	Wash water saturated with grease. Dirty tank. Weak sprays in wrong direction. Improper detergent mixture	Stop operation and clean all equipment. Adjust speed of conveyor. Examine spray equipment. Clean nozzles, spray pipes, scrap trays, and strainers. Check piping for leaks. Check to see if valves are operating properly. Examine pump. Clean impellor if necessary

Table R

Troubleshooting Chart for Ovens, Ranges, and Boilers

Trouble	Check	Cause
OIL-FIRED OVENS		
MOTOR: Will not start -	– Fuse. – Thermostat. – Solenoid valve. – Fuel tank.	Blown. Set below baking chamber temperature. Reset. Activated. Or foreign particles in valve. Empty.
Runs, but fails to light oven -	– Ignition. – Transformer. – Fuel nozzle.	Carbon on electrodes. Damaged, bad. Replace. Clogged. Clean.
COMBUSTION FLAME: Disorganized & smoky -	– Damper. – Flue pipes.	Closed. Heavy soot deposits.
UNEVEN COOKING:	– Secondary air damper door.	Too far open or too near shut. Adjust.
IGNITION: Difficult -	– Oil supply.	Too low. Open valve. Shut off by solenoid valve.
BURNER: Starts, functions properly, but fails after short intervals -	– Burner openings. – Suction line. – Strainers. – Oil tank vent. – Controls.	Dirty. Clean. Air leak. Repair. Clogged. Clean. Obstructed. Clean. Out of order or improperly adjusted. Poor or delayed. Clean nozzle.
Puffs when started -		Insufficient.
Runs, but flame pulsates -	– Ignition. – Draft. – Draft. – Chimney.	Insufficient. A downdraft.
COMBUSTION CHAMBER: Smoke in chamber or in chimney-	– Air. – Nozzle.	– Insufficient – Clogged or defective Replace
Carbon forms in chamber -	– Oil burning rate. – Nozzle (oil spray on walls)	– Excessive. Reduce. – Dirty or incorrect model. – Clean/Replace.

Table R

Troubleshooting Chart for Ovens, Ranges, and Boilers (Continued)

Trouble	Check	Cause
OIL-FIRED OVENS–Continued		
FIRE: On one side -	– Nozzle.	Dirty or damaged. Clean/replace.
OIL CONSUMPTION: High -	– Air – Heat-absorbing surfaces. – Oil storage tank.	Too little. Increase. Dirty. Clean ducts. Leaks. Repair.
SOLENOID VALVE: Fails to function -	– Valve itself. – Thermostat. – Connections. – Emergency bypass valve.	Dirty or defective. Replace Damaged. Replace. Defective. Replace. Open.
PILOT FLAME: Inoperative or too low -	– Fuel passage. – Solenoid valve.	Clogged. Clean. Adjust setscrew to increase fuel to pilot flame.
OVEN: Overheats - Underheats -	– Thermostat. – Solenoid valve. – Fuel line. – Fuel shutoff valve. – Vaporizing parts.	Damaged. Replace. Stuck plunger, Dirty. Clean. Clogged. Clean/replace. – Not fully open. – Full of carbon. Clean.
OVEN OR RANGE: Fails to ignite – Does not heat fast enough – Cooks unevenly – No gas –	– Pilot flame. – Main gas or shutoff valve. – Air shutter. – – Gas input. – Cooling damper. – – Flue. – Doors. – Bypass Flame. – Main service valve. – Solenoid valve.	– Insufficient or none. – Closed. (adjacent to unit) – Completely closed. – Too Low or out of adjustment. – Open. – Too much draft. (pulls heat through flue). – Don't close tightly. Clean, – Adjust. – Closed. – Clogged, dirty or defective. Clean/replace.

Table R

Troubleshooting Chart for Ovens, Ranges, and Boilers (Continued)

OVEN OR RANGE: Constant "burning"–	– Draft. – Thermostat.	– Too much. Remove Draft. – Faulty. Replace.
Temperature rises, when not in use –	– Low flame setting.	– Is too high. (Cut low flame to a minimum.)
Fumes in room –	– Chimney	– Faulty, backdraft or improper gas adjustment.
	– Fans in room.	– Running with doors and windows closed.
Flare back on turndown –	– Bypass flame.	– Too low, adjust.
FIELD RANGES		
FUEL SYSTEM; Fails to maintain pressure –	– Fuel filter. – Air valve. – Fuel tank.	– Leaks. Replace gasket. – Defective. Replace. – Defective. Replace.
PREHEATER: Fails to ignite –	– Safety valve. – Fuel feed tube assembly. – Preheater generator.	– Does not reseat. Replace. – Damaged or missing. Replace. – Defective. Replace.
BURNER: Fails to ignite –	– Preheater generator. – Generator. – Feed tube assembly.	– Defective. Replace. – Defective. Replace. – Missing, clogged or dented. Clean/Replace.
Flame too low –	– Generator.	– Defective.
BURNER FLAME: Yellow –	– Generator flame valve.	– Defective. Repack/replace.
GENERATOR OR PREHEATER VALVE: Fuel leaks –	– Generator flame valve. – Generator.	– Defective. Repack/replace. – Defective. Replace
AIR PRESSURE GAUGE: Pressure rises above safe limit -	– Valves.	– Defective. Repack or replace.
	– Fuel tank. – Gauge.	– Too full. Only 8 quarts. – Defective. Replace

Table S

Troubleshooting Chart for Clayton Steam Generator

Trouble	Possible Cause	Remedy
Feedwater pump failing to maintain proper water level in accumulator gauge glass.	Accumulator blowdown valve open or leaking.	Inspect accumulator blowdown valve.
	Feedwater pump not primed.	Prime pump.
	Insufficient water to feedwater pump.	Check water supply to pump. Ensure intake valve is open.
	.Feedwater strainer clogged.	Clean strainer.
	Feedwater pump check valves not operating properly	Clean and inspect check valves.
	Water pump solenoid not releasing.	Remove water level electrodes and clean off rust and dirt. Check water pump solenoid armature and linkage for binding.
Circulating pump failing to maintain proper feed volume to heating coil, causing thermostat interruption.	Low oil level in water pump causing reduced pump capacity.	Ensure oil is maintained at proper level.
	Priming valve not operating properly.	Clean and inspect priming valve.
	Circulating pump check valves not operating properly.	Clean and inspect check valves.
	Vapor lock of circulating pump due to abrupt steam demand causing low pressure in accumulator.	On installations where there are sudden heavy steam demands, a back pressure valve should be installed to retain a normal steam pressure in the accumulator during these periods.
	Circulating pump not primed.	Prime circulating pump.

Table S

Troubleshooting Chart for Clayton Steam Generator (Continued)

Water System		
Too much water (unit operating with high water level in gauge glass).	Water pump solenoid not operating.	1. Check for burned out solenoid coil or open circuit to solenoid. 2. Remove and clean water level electrodes. Corrosion on electrodes may cause insulating effect and prevent operation of solenoid. 3. Check for defective water level relay.
	Stream trap plugged.	Remove and clean steam trap.
Noisy water pump operation.	Flexible coupling loose between motor and pump.	Tighten setscrews in flexible coupling.
	Pump intake surge chamber fouled.	Check and clean intake surge chamber.
	Restricting heating coil causing excessive feed pressure.	Check feed pressure for coil restriction.
Water pump cycles rapidly.	Leads to water level electrodes reversed.	Check wiring to electrodes (see wiring diagram).

Table S

Troubleshooting Chart for Clayton Steam Generator (Continued)

Fuel System		
Trouble	**Possible Cause**	**Remedy**
Low or no fuel pressure. CAUTION: Stop plant immediately to avoid damage to the fuel pump.	Fuel supply exhausted or supply lines restricted.	Check fuel supply. Ensure all valves in the supply line are open.
	Fuel bypassing through burner control valve.	Burner control valve must be airtight and all air pockets eliminated.
	Fuel pressure not adjusted properly.	Adjust fuel pressure.
	Air leak in supply line causing loss of prime.	Suction line must be airtight and all air pockets eliminated.
	Fuel pump failure.	Replace fuel pump
Burner fails to ignite.	Faulty ignition.	Check and adjust ignition electrodes. Check ignition transformer and cable. Check for low voltage condition which may a weak spark from the transformer.
	Safety switch in combustion control locked out.	Actuate reset on control. Also check for continuity of circuit between combustion control and flame detector (under burner manifold).
	Fuel pressure switch failure.	Check and adjust fuel pressure switch.
	Burner nozzles not replaced in burner.	Ensure nozzles are replaced after cleaning burner manifold.
	Insufficient fuel pressure.	Check causes and remedies under "Low or No Fuel Pressure."
	Oil valve failing to open.	Check for burned out solenoid.

Table S

Troubleshooting Chart for Clayton Steam Generator (Continued)

Fuel System		
Trouble	**Possible Cause**	**Remedy**
Partial or improper burner operation causing low steam pressure at normal load.	Low fuel pressure.	Check causes and remedies under "Low or No Fuel Pressure."
Burner shuts off before maximum steam pressure is reached.	Thermostat control interruption due to low water condition.	Correct cause of low water condition immediately. Test thermostat for proper control.
Smoke from flue outlet. To prevent sooting of the heating coil and burner, correct this condition immediately.	Improper air supply to burner.	Check air adjustment/
	Fuel pressure not adjusted properly.	Adjust fuel pressure.
	Carboned, loose, or worn burner nozzles.	Clean and tighten burner nozzles. Replace if worn.
	Heating coil sooted.	Remove soot from heating coil.
	Dirt or sludge in fuel oil or incorrect grade of fuel used.	Ensure fuel is clean and is the proper grade.
Fluttering burner shuts off during automatic operation.	Oil valve not seating properly.	Check and clean solenoid valve.
Oil drip from burner.	Oil valve not seating properly.	Check and clean solenoid valve.
Dead or fluttering fire.	Heating coil sooted.	Remove soot.
	Improper air adjustment.	Check air adjustment.
Motor fails to start, or stops during operation	Power failure or tripped circuit breaker.	Check power lines. Reset circuit breaker.
	Safety shutdown caused by overload relays	Wait 2 or 3 minutes for overloads to cool; then press reset on magnetic controller and restart unit. Check for cause of overload
Motor noisy or running hot.	Motor running single phase	Check for blown fuse or tripped circuit breaker in feeder lines.
Magnetic controller fails to contact.	Operating coil failure.	Replace coil.

Table T

Troubleshooting Chart for Washers

Problem	Check	Cause
Motor will not run.	Power to machine. Door switch Water level control Motor Timer	None, check outlet Defective, check all controls Faulty, replace Faulty, repair or replace Faulty, replace
Machine will not shut off.	Timer Wiring	Defective, replace Break, repair Faulty, replace
Timer will not advance to next cycle. NOTE: Timer does not advance during water fill period until the water level switch has been satisfied.	Timer motor Timer Water level control	Defective, replace Bound shaft or knob, clear Faulty, replace
Incorrect fill or temperature	Water level control Thermal element Hot-water supply Hoses	Faulty water level control. Faulty, repair or replace Inadequate, adjust temperature Reversed, correct
No water	Water valves Hoses Fill hose screen Fill solenoid Water level control Machine	Closed, Turn on valves. Unkink hoses. Clean dut screen. Replace solenoid. Replace control. Check controls and power at outlet.
Water will not shut off.	Timer Water level control Mix and fill valve Valve	Defective, replace Defective, replace Foreign particles, clean Defective, replace

Table T

Troubleshooting Chart for Washers (Continued)

Problem	Check	Cause
Water will not drain from washer	Drain hose Pump Suds Transfer valve Timer Belt	Kinked/clogged, unkink/clear Does not run, readjust and tighten Lock, remove suds, add cold water Faulty, replace Defective, replace Loose, adjust
No spray rinse	Water supply Timer	None, same as no water Defective, replace
Slow spin	Belt/clutch	Slips, adjust
Excessive vibration	Washer Flooring Load Washer feet Snubber or suspension bolts	Not level, adjust legs Weak, reinforce floor Unbalanced, redistribute No rubber cups, install them Damaged, replace
No agitation	Motor Timer contacts. Faulty transmission. Defective control solenoid. Linkage Water level switch	Failure, repair or replace. Faulty, replace timer. Faulty, repair or replace Defective, replace solenoids. Broken, repair or replace. Faulty, replace switch
Water leakage.	Inlet hose Drain hoses Hose Gasket Housing	Loosely connected, tighten Loosely connected, tighten Broken, repair or replace Leaky, replace Cracked, replace parts
No recirculation of water during agitation	Pump Pump drive Hose Distribution valve	Jammed, clean Defective, replace coupling or tighten Clogged, clean Defective, clean out, replace valve or solenoid
Torn clothing	Bleach Agitator Basket	Improper usage Broken, replace Defective, replace

Table U

Troubleshooting Chart for Residential Dryers

Problem	What to check for
Motor does not start	Service cord disconnected Circuit breaker tripped or a blown fuse Wiring loose or broken Loading door open Door switch defective Motor defective
Dryer does not shut off	Timer motor jammed Clock spring broken Stop pin in improper positioning Timer contact points are closed Motor grounded or windings shorted out
Dryer dries slowly	Clothes are too wet Lint box is clogged Thermostat is set too low Voltage is low Dryer is overloaded
Dryer is noisy	Suction fan alignment is incorrect Loose fan or loose fan pulley Loose or dry fan belt There are loose items between the drum and the cylinder Loose screws

Table V

Troubleshooting Checklist for Refrigeration Systems

TROUBLE	POSSIBLE CAUSE	CORRECTIVE MEASURE
High condensing pressure.	Air or non-condensable gas in system.	Purge air from condenser.
	Inlet water warm.	Increase quantity of condensing water.
	Insufficient water flowing through condenser	Increase quantity of water.
	Condenser tubes clogged or scaled	Clean condenser water tubes.
	Too much liquid in receiver, condenser tubes submerged in liquid refrigerant.	Draw off liquid into service cylinder.
	Insufficient cooling of air-cooled condenser	Check fan operation, cleanliness of condenser, and for adequate source of air flow
Low condensing pressure.	Too much water flowing through condenser	Reduce quantity of water
	Water too cold.	Reduce quantity of water
	Liquid refrigerant flooding back from evaporator.	Change expansion valve adjustment, examine fastening of thermal bulb.
	Leaky discharge valve	Remove head, examine valves. Replace anv found defective.
High auction pressure.	Overfeeding of expansion valve.	Regulate expansion valve, .check bulb attachment.
	Leaky suction valve.	Remove head, examine valve and replace if worn.
Low suction pressure.	Restricted liquid line and expansion valve or suction screens.	Pump down, remove, examineand clean screens.
	Insufficient refrigerant in system.	Check for refrigerant storage.
	Too much oil circulating in system.	Check for too much oil in circulation. Remove oil.
	Improper adjustment of expansion valves.	Adjust valve to give more flow.
	Expansion valve power element dead or weak.	Replace expansion valve power element
	Low refrigerant charge.	Locate and repair leaks. Charge refrigerant.

Table V

Troubleshooting Checklist for Refrigeration Systems (Continued)

TROUBLE	POSSIBLE CAUSE	CORRECTIVE MEASURE
Compressor short cycles on low-pressure control.	Thermal expansion valve not feeding properly. 1. Dirty strainers. 2. Moisture frozen in orifice or orifice plugged with dirt. 3. Power element dead or weak.	Adjust, repair, or replace thermal expansion valve. 1. Clean strainers. 2. Remove moisture or dirt (Use system dehydrator). 3. Replace power element.
Compressor short cycles on low-pressure control (continued)..	Water flow through evaporators restricted or stopped. Evaporator coils plugged, dirty, or clogged with frost	Remove restriction. Check water flow. Clean coils or tubes.
	Defective low-pressure control switch.	Repair or replace low-pressure control switch.
Compressor runs continuously.	Shortage of refrigerant.	Repair leak and recharge system.
	Leaking discharge valves.	Replace discharge valves.
Compressor short cycles on high-pressure control switch.	Insufficient water flowing through condenser, clogged condenser.	Determine if water has been turned off. Check for scaled or fouled condenser.
	Defective high-pressure control switch.	Repair or replace high-pressure control switch.

Table V

Troubleshooting Checklist for Refrigeration Systems (Continued)

TROUBLE	POSSIBLE CAUSE	CORRECTIVE MEASURE
Compressor will not run.	Seized compressor.	Repair or replace compressor.
	Cut-in point of low-pressure control switch too high. High-pressure control switch does not cut-in. 1. Defective switch. 2. Electric power cut off. 3. Service or disconnect switch open. 4. Fuses blown. 5. Overload relays tripped. 6. Low voltage. 7. Electrical motor in trouble. 8. Trouble in starting switch or control circuit. 9. Compressor motor stopped by oil-pressure differential switch.	Set L.P. control switch to cut-in at correct pressure. Check discharge pressure and reset H.P. control switch. 1. Repair or replace switch. 2. Check power supply. 3. Close switches. 4. Test fuses and renew if necessary. 5. Reset relays and find cause of overload. 6. Check voltage (should be within 10 percent of nameplate rating). 7. Repair or replace motor. 8. Close switch manually to test power supply. If OK check control circuit including temperature and pressure controls. 9. Check oil levels in crankcase. Check oil pressure.
Sudden loss of oil from crankcase.	Liquid refrigerant slugging back to compressor crankcase.	Adjust or replace expansion valve.

Table V

Troubleshooting Checklist for Refrigeration Systems (Continued)

TROUBLE	POSSIBLE CAUSE	CORRECTIVE MEASURE
Capacity reduction system fails	Hand-operating stem of capacity control valve not turned to automatic position.	Set hand-operating stem to automatic position.
Compressor continues to operate at full or partial load.	Pressure-regulating valve not opening.	Adjust or repair pressure-regulating valve.
Capacity reduction system fails to load cylinders.	Broken or leaking oil tube between pump and power element.	Repair leak.
Compressor continues to operate unloaded.	Pressure regulating valve not clossing.	Adjust or repair pressure regulating valve.

Table W

Troubleshooting Industrial Refrigeration

PROBLEM	POSSIBLE CAUSE	REMEDY
Compressor will not start	No power to motor	Check power to and from fuses; replace fuses if necessary Check starter contacts, connections, overloads, and timer (if part winding start). Reset or repair as necessary. Check power at motor terminals. Repair wiring, if damaged.
	Control circuit is open	Safety switches are holding circuit open. Check high pressure, oil failure, and low-pressure switches. Also check oil filter pressure differential switch is supplied. Thermostat is satisfied. Check control circuit fuses if blown; replace. Check wiring for open circuit.
Motor "hums" but does not start	Low voltage to motor	Check incoming power for correct voltage. Call power company or inspect/repair power wiring. Check at motor terminals. Repair or replace as necessary.
	Motor shorted	Check at motor terminals. Repair or replace as necessary
	Single-phase failure in the three-phase power supply	Check power wiring circuit for component or fuse failure.
	Compressor is seized due to damage or liquid	Remove belts or coupling. Manually turn crankshaft to check compressor.
	Compressor is not unloaded	Check unloader system.
Compressor starts but motor cycles off on overloads	Compressor has liquid or oil in cylinders	Check compressor crankcase temperature. Throttle suction stop valve on compressor to clear cylinders and act to prevent recurrence of liquid accumulation.
	Suction pressure is too high	Unload compressor when starting. Use internal unloaders if present. Install external bypass unloader.
	Motor control	Motor control located in hot ambient. Low voltage. Motor overloads may be defective or weak. Check motor control relay. Adjust circuit breaker setting to full load amps.
	Bearings are "tight"	Check motor and compressor bearings for temperature. Lubricate motor bearings.
	Motor is running on single-phase power	Check power lines, fuses, starter, motor, etc., to determine where open circuit has occurred.
Compressor starts but short cycles automatically	Low refrigerant charge	Check and add if necessary.
	Driers plugged or saturated with moisture	Replace cores.

Table W

Troubleshooting Industrial Refrigeration (Continued)

PROBLEM	POSSIBLE CAUSE	REMEDY OR COMMENT
Compressor starts but short cycles automatically (continued).	Refrigerant feed control is defective	Repair or replace
	No load	To prevent short cycling, if objectionable, install pump-down circuit, anti-recycle timer or false load system.
	Unit is too large for load	Reduce compressor speed. Install false load system.
	Suction strainer blocked or restricted	Check and clean or replace as necessary.
Motor is noisy or erratic	Motor bearing failure or winding failure	Check and repair as needed.
	If electric starter, check calibration on control elements	Adjust as necessary
Compressor runs continuously but does not keep up with the load	Load is too high	Speed up compressor or add compressor capacity. Reduce load.
	Refrigerant metering device is underfeeding, causing compressor to run at too low a suction pressure	Check and repair liquid feed problems. Check discharge pressure and increase if low.
	Faulty control circuit, may be low pressure control or capacity controls	Check and repair.
	Compressor may have broken valve plates.	Check compressor for condition of parts. This condition can usually be detected by checking compressor discharge temperature.
	Thermostat control is defective and keeps unit running	Check temperatures of product or space and compare with thermostat control. Replace or readjust thermostat.
	Defrost system on evaporator not working properly	Check and repair as needed.
	Suction bags in strainers are dirty and restrict gas flow	Clean or remove.
	Hot gas bypass or false load valve stuck	Check and repair or replace.
Compressor loses excessive amount of oil	High suction superheat causes oil to vaporize	Insulate suction lines. Adjust expansion valves to proper superheat. Install liquid injection (suction line desuperheating).
	Too low of an operating level in chiller will keep oil in vessel	Raise liquid level in flooded evaporator (R-12 systems only).
	Oil not returning from compressor	Make sure all valves are open Check float mechanism and clean orifice. Checka nd clean return line.

Table W

Troubleshooting Industrial Refrigeration (Continued)

PROBLEM	POSSIBLE CAUSE	REMEDY OR COMMENT
Compressor loses excessive amount of oil (continued).	Oil separator is too small	Check selection.
	Broken valves cause excessive heat in compressor and vaporization of oil.	Repair compressor.
	"Slugging" of compressor with liquid refrigerant that causes excessive foam in the crankcase	"Dry up" suction gas to compressor by repairing evaporator. Refrigerant feed controls are overfeeding. Check suction trap level controls. Install a refrigerant liquid transfer system to return liquid to high side.
Noisy compressor operation	Loose flywheel or coupling	Tighten.
	Coupling not properly aligned	Check and align if required.
	Loose belts	Align and tighten per specs. Check sheave grooves.
	Poor foundation or mounting	Tighten mounting bolts, grout base, or install heavier foundation.
	Check compressor with stethoscope if noise is internal	Open, inspect, and repair as necessary.
	Check for liquid or oil slugging	Eliminate liquid from suction mains. Check crankcase oil level.
Low evaporator capacity	Inadequate refrigerant feed to evaporators	Clean strainers and driers. Check expansion valve superheat setting. Check for excessive pressure drop due to change in elevation, too small of lines (suction and liquid lines). A heat exchanger may correct this. Check expansion valve size.
	Expansion valve bulb in a trap	Change piping or bulb location to correct.
	Oil in evaporator	Warm the evaporator, drain oil, and install an oil trap to collect oil.
	Evaporator surface fouled	Clean.
	Air or product velocity is too low	Increase to rated velocity. Coil not properly defrosting. Check defrost time. Check method of defrost.
	Brine flow through evaporator may be restricted	Chiller may be fouled or plugged. Check recirculating pumps. Check process piping for restriction.
Discharge pressure too high	Air in condenser	Purge noncondensibles.
	Condenser tubes fouled	Clean.
	Water flow is inadequate	Check water supply and pump.

Table W

Troubleshooting Industrial Refrigeration (Continued)

PROBLEM	POSSIBLE CAUSE	REMEDY OR COMMENT
Discharge pressure too high (continued).	Water flow is inadequate (continued).	Check control valve. Check water temperature.
	Airflow is restricted	Check and clean: Coils. Eliminators. Dampers.
	Liquid refrigerant backed up in condenser	Find source of restriction and clear. If system is overcharged, remove refrigerant as required. Check to make sure equalizer (vent) line is properly installed and sized.
	Spray nozzles on condensers plugged	Clean.
Discharge pressure too low	Ambient air is too cold	Install a fan cycling control system.
	Water quantity not being regulated properly through condenser	Install or repair water regulating valve.
	Refrigerant level low	Check for liquid seal, add refrigerant if necessary
	Evap condenser fan and water switches are improperly set	Reset condenser controls.
Suction pressure too low	Light load condition	Shut off some compressors. Unload compressors. Slow down RPM of compressor. Check process flows.
	Short of refrigerant	Add if necessary
	Evaporators not getting enough refrigerant	Discharge pressure too low. Increase to maintain adequate refrigerant flow. Check liquid feed lines for adequate refrigerant supply. Check liquid line driers.
	Refrigerant metering controls are too small	Check superheat or liquid level and correct as indicated.
Suction pressure too high	Low compressor capacity	Check compressors for possible internal damage Check system load. Add more compressor capacity.

Table X

Troubleshooting Laundry Equipment

WASHERS		
TROUBLE	**CHECK**	**PROBLEM**
DRAIN VALVE FAILURE:		
Drain fails to close -	– Master switch.	– Turned OFF.
	– Drain switch.	– At OPEN.
	– Drain finger.	– Not touching the timer cylinder or touching at a dirty spot.
	– Interior light not lit.	– Drain relay not working, or contacts are dirty.
	– Pilot solenoid valve not working.	– No voltage, or valve piston stuck.
	– Low air or water pressure.	– Adjust pressure regulator.
	– Piston cup.	– Needs replacement.
Drain fails to open -	– Exhaust line from pilot valve to soap chute.	– Clogged.
	– Drain valve.	– Rusted or broken spring.
	– Drain valve cylinder.	– Dented.
	– Pressure regulator.	– Faulty.
WATER VALVE FAILURE:		
Valve fails to open –		
	– Master switch.	– Turned OFF.
	– Appropriate water switch.	– Turned OFF.
	– Water finger.	– Not touching the timer cylinder or touching at a dirty spot.
	– Drain valve.	– Is OPEN.
	– Valve itself.	– Shorted coil or broken wire to inlet valves.
	– Pilot orifice in inlet of valve.	– Clogged.
	– Valve piston.	– Binding.
	– Water pressure.	– Too high.
	– Water level control.	– Not operating due to float binding.
Valve fails to close -	– Level control switches (inside).	– Not operating.
	– Water pressure.	– Extremely low.
	– Strainers, water inlet line.	– Dirty or clogged.
	– Water valve coil.	– Short or ground.
	– Water pressure.	– Extremely low.
	– Piston return spring (valve).	– Broken.
	– Piston or pilot orifice.	– Clogged.
	– Level control float chamber.	– Clogged.
	– Level control float.	– Cracked or faulty.
	– Float rod adjusting collars.	– Set too close together.

Table X

Troubleshooting Laundry Equipment (Continued)

WASHER		
TROUBLE	**CHECK**	**PROBLEM**
TIMER CYLINDER:		
Does not turn –	– Master switch.	– Not at formula.
	– Water level.	– Not attained.
	– Zero level starching.	– Improper switch position.
	– Clutch (joins the timer motor shaft to the time cylinder).	– Loose setscrew.
	– Timer motor.	– No voltage.
	– Timer cylinder motor.	– Bad. Replace motor and gear case.
AUTOMATIC CONTROLS:		
(washer cylinder running)		– Defective.
Do not operate –	– Transformer.	– Faulty drain relay or drain finger does not touch the drain cylinder screen.
	– Signals operate.	– At OPEN.
	– Drain switch.	
MILTROL:		– Faulty.
Operates but does not run, or runs in one direction –	– Reversing control timer motor.	– Burned out.
	– Reversing control contactor coil.	
	– Microswitch (on reversing control cam mechanism).	– Faulty.
	– Voltage.	– Low.
	– Wiring.	– Broken or shorted.
	– Signal relay or contacts.	– Faulty or dirty contacts.

Table X

Troubleshooting Laundry Equipment (Continued)

WASHER		
TROUBLE	**CHECK**	**PROBLEM**
MOTOR:		
Fails to start –	– Power.	– Failure.
(20, 26 inch models & 30 inch manual brake machines)	– Line fuses.	– Blown.
	– Overload relay.	– Tripped.
	– Wiring.	– Loose or broken connections.
	– Microswitch.	– Not actuating properly.
Fails to start –		
(26 & 30 inch automatic brake machines)	– Interlock switch.	– Faulty.
	– Brake air cylinder.	– Piston cup binding.
	– Brake "VN".	– Locked manually.
MOTOR RUNS:		–
Machine fails to come up to speed-		
	– Load.	– Not properly balanced.
	– Voltage.	– Low or frequency low.
	– Connections in switches or wiring.	– Loose or broken in switch or wiring.
	– Fuses.	– Blown.
	– Commutator brushes.	– Dirty or worn.
BRAKE NOT RELEASING:	– Interlock or brake shoes.	– Dragging.
Extractor turned on:	– Curb in basket.	– Jammed by foreign materials.
(20 inch)		
	– Brake mechanism.	– Solenoid plunger binding.
	– Voltage.	– Low or low frequency.
Extractor turned on –	– Brake pressure spring.	– Too much tension.
(26 & 30 inch)	– Solenoid wiring.	– Loose connection.
	– Exhaust port or pilot solenoid valve.	– Clogged.
	– Microswitch.	– Bad.
	– Pilot solenoid valve.	– Jammed open.
EXTRACTOR RUNNING:		
Makes knocking noise –	– Floor mounting.	– Not properly bolted.
	– Packing nut.	– Loose.
	– Spindle pulley.	– Loose on spindle.
	– Rubbers.	– Worn.
	– Basket.	– Loose on spindle.
EXTRACTOR NORMAL	– Bearings.	– Bad.
OUT-OF-BALANCE LOAD:	– Motor pulley.	– Loose on shaft.
Fails to carry –	– Rubbers.	– Too loose or too tight.
	– Motor.	– Not developing full power.
	– Brake.	– Not fully releasing when motor is turned on.
	– Floor mounting.	– Not fully bolted down.

Table Y

Troubleshooting Checklist for Domestic Refrigerators and Freezers

Trouble	Possible Causes	What to look for and what to do
1. Unit fails to start	Wiring	Loose connections, broken wires, grounded leads, open contacts, blown fuses, poor plug contacts, poorly soldered connections. Correct defects found.
	Low voltage	Rated voltage should be ± 10 percent. Overloaded circuits; read the voltage across the compressor-motor terminals; if it reads 100 volts or under, the circuit is overloaded. Check the voltage at the fuse panel; if this voltage is low, the power supply voltage needs correction. Provide a separate circuit for the unit.
	Compressor motor	Remove leads from the compressor motor. Apply 115 volts to the motor running winding terminals on the terminal plate from a separate two-conductor cable. Then, touch a jumper wire across both the starting and the running winding terminals. If the motor starts and runs, the trouble is isolated in the control or in the compressor motor thermostat. If the unit does not start, replace it.
	Motor thermostat	Connect a jumper to shunt the thermostat from the line-side terminal of the thermostat across to the common terminal of the compressor motor. If the compressor starts, the thermostat is open and should be replaced. Do not attempt to correct calibration of the thermostat. Replace the thermostat.
2. Unit runs normally but temperature is too high	Temperature selector control set too high	Reset the dial to its normal position.
	Temperature control out of adjustment	Readjust in accordance with the manufacturer's instructions.
	Poor air circulation in the cabinet	Paper on shelves; too much food in storage; other obstructions to proper air circulation. Maintain sufficient space in the cabinet for proper air' circulation.
	Damper control faulty	On models with this type of control it is best to replace the control or to follow the manufacturer's instructions.
3. Unit runs normally but temperature is too low	Temperature selector control out of adjustment	Reset the control to a higher position.
	Temperature control out of adjustment	Readjust the control in accordance with the manufacturer's instructions
4. Unit runs too long and temperature is too low	Temperature bulb improperly located or defective	Replace or relocate the bulb in accordance with the manufacturer's instructions. Be sure the bulb is securely attached to the evaporator. Replace defective bulbs.
	Compressor	Refer to item 7.

Table Y

Troubleshooting Checklist for Domestic Refrigerators and Freezers (Continued)

Trouble	Possible Causes	What to look for and what to do
5. Unit does not run and temperature is too high	No power at outlet	Check the fuses, and replace burned-out ones.
	Poor plug contact	Spread the plug contacts.
	Control in "Off" position	Turn to the "Coldest" position, then back to the “Normal” position
	Temperature control inoperative	Examine the control main contacts; clean them with a magneto file or with fine sandpaper; replace them if they are badly burned or pitted. Do not use emery cloth. Check and replace the relay assembly, if necessary. If the temperature control main contacts are found open, try warming the temperature control bulb by hand. If this does not close the control contacts, the control bellows has lost its charge, and the control should be replaced.
	Pressures in system not equalized	Wait for a period of about 5 minutes before trying to restart the unit. See item 3.
	Open circuit in wiring	Make voltmeter or test-lamp checks to determine whether any part of the electrical wiring system is open, or any controls are inoperative. Correct defective connections, and replace worn or damaged controls
	Compressor thermostat open	See item 1.
	Open motor windings	See item 1.
6. Unit runs for short periods; temperature too high	Defrosting heater	On a unit equipped with a defrosting heater, check the defrosting cycle in accordance with the manufacturer’s instructions. Ascertain whether the defrosting heater is turned off by making sure that no current flows through it during the refrigerating cycle.
	Unit operates on thermostat	See item 9.
7. Unit runs continuously; temperature too high	Moisture, obstruction, or restriction in liquid line	Before checking for moisture, be certain that the symptoms observed are not caused by improper operation of the defrosting heater, if so equipped. These heaters are wired into the cabinet wiring so that the control contacts short out the heaters when the contacts are closed. Thus the heaters are on only when the machine is off, when the control contacts open, and when the evaporator is on the defrost cycle. Check the control contacts to see that the defrosting heaters are off when the machine is running. At high ambient temperature, the unit will cycle on its thermostat. The evaporator will warm up over its entire surface is the liquid circulation is completely obstructed. If it is only partly obstructed, a part of the frost on the evaporator will melt. Under these conditions, the unit will probably operate noisily, and the motor will tend to draw a heavy current. If the liquid line is obstructed by ice, this ice will melt after the unit has warmed up. The unit will then refrigerate normally. If this obstruction occurs too frequently and spare units are available, replace the unit.
	Broken valves	Exceedingly high current to the motor. No cooling in the evaporator and no heating in the condenser. Excessive compressor noise. Replace the hermetic compressor or replace the valves in an open-type compressor.
	Clogged tubing	Check the tubing for damage, sharp bends, kinks, pinches, etc. Straighten the tubing, if possible, or replace the unit.

Table Y

Troubleshooting Checklist for Domestic Refrigerators and Freezers (Continued)

Trouble	Possible Causes	What to look for and what to do
7. Unit runs continuously; temperature too high (Continued)	Refrigerant leaks or undercharged	The unit may tend to run normally but more frequently. The evaporator becomes only partly covered with frost. The frost will tend to build up nearest to the capillary tube while the section nearest to the suction line will be free from frost. As leakage continues, the frostline will move back across the evaporator. When the refrigerant is entirely gone, no refrigeration will occur. Units with large evaporators will not frost up unless the evaporator is mounted inside of the box. Test for leaks with a halide leak detector. Recharge the unit, if necessary.
	Cabinet light	Check the operation of the light switch, see that the light goes out as the door is closed.
	Air circulation	See that sufficient space is allowed for air circulation. Relocate or reposition the unit, if possible.
	Evaporator needs defrosting	Advise the user on defrosting instructions.
	Gasket seals	Give them a thorough cleaning. If worn they should be replaced.
	Ambient temperature	Relocated the unit tin a location where the ambient temperature ranges from 55 degrees to 95 degrees
	Defroster heater	On units so equipped, check the defroster heater circuit. See item 6.
	Compressor suction valves sticks open or is obstructed by corrosion or dirt	Ascertain whether the condenser gets warm, and check the current drawn by the motor. If the condenser does not get warm and the current drawn is low, disassemble the compressor (open type) and check the action of the suction valve
	Compressor discharge valve sticks open or is obstructed	Connect the test gauge assembly, run the unit until the low-side pressure is normal. With an ear in close proximity to the compressor, listen for a hissing sound of escaping gas past the discharge valve. The low-side pressure gauge will rise, and the high side will drop equally until both are the same. Clean out obstructions.
8. Unit runs too long; temperature too high	Condenser	Check for any obstruction in the path of air circulation around the condenser. Clean any dust accumulation.
	Fan	On units so equipped, check to see that the fan blades are free to turn and that the fan motor operates.
	Door seal	Clean seals around the door. Check closure of the door with a strip of paper between the gasket and the cabinet at all points around the door. The gasket should grip the paper tightly at all points.
	Refrigerant	Check for leakage and undercharge of the refrigerant. See item 7.
	User	Warn the user against too frequent opening of the door, storage of hot foods, heavy freezing loads, and other improper usage.
9. Unit operates on thermostat; temperature too high	Voltage	Check voltage ± 10 percent of rating.
	Defrosting heater	See that the defrosting heater is turned off.
	Starting relay	Determine that the starting relay does not stick closed. Follow the manufacturer's instructions on methods of checking.

Table Y

Troubleshooting Checklist for Domestic Refrigerators and Freezers (Continued)

Trouble	Possible Causes	What to look for and what to do
9. Unit operates on thermostat; temperature too high (Continued)	Condenser	Check the air circulation around the condenser; also check the operation of the fan.
	Pressures not equalized	Wait 5 minutes after stopping, then restart; turn to the coldest position, then to the normal position
	Restrictions in liquid line	See item 7.
	Thermostat	Thermostat may be out of calibration. Replace the thermostat.
10. Noisy operation	Fan blades	If the blades are bent, realign them, and remove any obstructions. If the blades are so badly bent or warped that they cannot be realigned, they should be replaced.
	Fan motor	Check the motor mounting and tighten the connections.
	Tube rattling	Adjust the tubes so that they do not rub together.
	Food shelves	Adjust them to fit tightly.
	Compressor	Malfunctioning valves; loose bolted connections; improper alignment of open-type compressor. Replace the hermetic compressor tighten the connections; realign the open-type compressor
	Floor or walls	Check to see that the floor is rigid, and whether the walls vibrate. Locate and correct any such sources of noise. Make corrections by bolting or nailing loose portions to structural members.
	Belt	Check the condition of the motor belt. Replace it when it becomes worn or frayed.
11. Unit uses too much electricity	Door	Check the door seal. See item 7.
	Usage	Instruct the user on proper usage of the motor. See item 8. Check the overload.
	Ambient temperature too high	See item 7. The unit will operate more frequently and over longer periods of time in a high-temperature atmosphere. Correct, if possible, by changing the location of the unit.
	Defrost control	Check the defrost circuit according to the manufacturer's instructions
	Temperature control	Selector control dial set too low. Advise the user. Operate it as near to the "Normal" setting as possible.
12. Stained ice trays	Poor cleaning procedures	Use soap and warm water to wash trays. Rinse them thoroughly. Do not use metal sponges, steel wool, or course cleaning powders.

Table Z

Troubleshooting Chart for Air Conditioners

Type of Unit	Complaint	Cause	Possible Remedy
With open-type compressor	Electric motor will not start	Power failure	Check circuit for power source
		Compressor stuck	Locate cause and repair
		Belt too tight	Adjust belt tension
		Manual reset in starter open	Determine cause of overload and repair. Reset overload cutout
		Thermostat setting too high	Lower thermostat setting
		Low voltage	Check with voltmeter, then call power company
		Burned-out motor	Repair or replace
		Frozen compressor caused by locked or damaged mechanism	Remove and repair compressor
	Unit cycles on and off	Intermittent power interruption	Tighten connections or replace defective power supply parts
		High-pressure cutout defective	Replace high-pressure cutout
		High-pressure cutout set too low. Overload opens after having been reset	Raise cutout pressure. Check voltage and current drawn
		Leaky liquid-line solenoid valve	Repair or replace
		Dirty or iced evaporator	Clean or defrost evaporator. Check filters and fan drive
		Overcharge or refrigerant or non-condensable gas	Remove excess refrigerant or purge non-condensable gas
		Lack or refrigerant	Repair refrigerant leak and recharge
		Restricted liquid-line strainer	Clean strainer
		Faulty motor	Repair or replace faulty motor
	Coil frosts	Filters dirty	Clean filters
		Not enough air over coil	Clean or remove restriction from supply or return ducts or grilles
		Defective expansion valve	Replace valve

Table Z

Troubleshooting Chart for Air Conditioners (Continued)

Type of Unit	Complaint	Cause	Possible Remedy
With open-type compressor (continued)	Unit runs but will not cool	Unit not fully charged	Recharge slightly, then check for leaks in the refrigerant circuit, then fully charge
		Leaky suction valve	Remove compressor cylinder head and clean or replace valve plate
		Expansion valve not set correctly	Adjust expansion valve
		Strainer clogged	Remove, clean, and replace valve
		Air in refrigerant circuit. Moisture in expansion-valve orifice	Purge unit of air. Clean orifice and install silica gel dryer
		Flash gas in liquid line	Add refrigerant
	No air blows from supply grille	Ice or dirt on evaporator	Clean coil or defrost
		Blower belt broken or loose	Adjust belt tension, or replace belt
		Blower bearing frozen	Repair or replace bearing and lubricate as directed
	Discharge pressure too high	Improper operation of condenser	Correct airflow. Clean coil surface
		Air in system	Purge
		Overcharge of refrigerant	Remove excess or purge
	Discharge pressure too low	Lack of refrigerant	Repair leak and charge
		Broken or leaky compressor discharge valves	Remove head, examine valves and replace those found to be operating improperly
	Suction pressure too high	Overfeeding of expansion valve	Regulate superheat setting expansion valve and check to see that remove bulb is properly attached to suction line
		Expansion valve stuck in open position	Repair or replace valve
		Broken suction valves in compressor	Remove head, examine valves and replace those found to be inoperative
	Suction pressure too low	Lack of refrigerant	Repair leak and charge
		Clogged liquid line strainer	Clean strainer
		Expansion-valve power assembly has lost charge	Replace expansion-valve power assembly
		Obstructed expansion valve	Clean valve and replace if necessary
		Contacts on control thermostat stuck on closed position	Repair thermostat or replace if necessary

Table Z

Troubleshooting Chart for Air Conditioners (Continued)

Type of Unit	Complaint	Cause	Possible Remedy
With hermetic motor-compressor combination (continued)	Compressor runs continuously; good refrigeration effect	Air over condenser restricted	Remove restriction or provide for more air circulation over the condenser
	Compressor runs continuously; unit is too cold	Thermostatic switch contacts badly burned	Replace thermostatic switch
		Thermostatic switch bulb has become loose	Secure bulb in place
		Thermostatic switch improperly adjusted	Readjust thermostatic switch
	Compressor runs continuously; little refrigeration effect	Extremely dirty condenser	Clean condenser
		No air circulating over condenser	Provide air circulation
		Ambient temperature too high	Provide ventilation or move to a cooler location
		Load too great	Analyze load
	Compressor runs continuously; no refrigeration	A restriction that prevents the refrigerant from entering the evaporator. A restriction is usually indicated by a slight refrigeration effect at the point of restriction	Locate the possible points of restriction, and try jarring it with a plastic hammer, or heating to a temperature of about 110 degrees F. If the restriction does not open, replace the unit.
		Compressor not pumping. A cool discharge line and a hot compressor housing would indicate this. The wattage is generally low.	Replace the unit
		Short of refrigerant	See manufacturer's instructions
	Compressor short cycles, poor refrigeration effect	Loose electrical connections	Locate loose connections and make them secure
		Defective thermostatic switch	Replace thermostatic switch
		Defective motor starter	Replace defective motor starter or relay
		Air restriction at evaporator	Remove air restriction

Table Z

Troubleshooting Chart for Air Conditioners (Continued)

Type of Unit	Complaint	Cause	Possible Remedy
With hermetic motor-compressor combination (continued)	Compressor short cycles, no refrigeration	Dirty condenser	Clean the condenser
		Ambient temperature too high	Provide ventilation or move to a cooler location
		Defective wiring	Repair or replace defective wiring
		Thermostatic switch operating erratically	Replace thermostatic switch
		Relay erratic	Replace relay
	Compressor runs too frequently	Poor air circulation around the condenser or too high ambient temperature	Increase the air circulation around the condenser. In some localities the temperature is extremely high, and nothing can be done to correct this
		Load too great. Worn compressor. Generally accompanied by rattles and knocks	Analyze end use. Replace unit or bring it to the shop for repairs
	Compressor does not run	Motor is not operating	If the trouble is outside the sealed unit, it should be corrected; for example, wires should be repaired or replace and thermostatic switches or relays should be replaced. If the trouble is inside the sealed unit, the sealed unit should be replaced.
	Compressor will not run (Assume that the thermostatic switch and relay, and the electric wiring and current supply are in good condition and operating normally)	If the cabinet has been moved, some oil may be on top of the piston	Wait an hour or so, and then attempt to start the motor by turning the current on and off many times. On some compressors, it may be necessary to wait 6 or 8 hour
		Compressor may be stuck, or some parts may be broken	Replace the unit
		Connections may be broken on the inside of the unit, or the motor winding may be open	Replace the unit. Sometimes after sealed units have been standing idle for a long time, the piston may be stuck in the cylinder wall. It is sometimes possible to start the compressor by turning on the current and bumping the outer housing with a rubber mallet.
	Compressor is unusually hot	Condenser is dirty, or there is a lack of air circulation	Clean the condenser; increase the air circulation

Table Z

Troubleshooting Chart for Air Conditioners (Continued)

Type of Unit	Complaint	Cause	Possible Remedy
With hermetic motor-compressor combination (continued)		Unusually heavy service or load	If possible, decrease load. Perhaps another unit is required
		Low voltage	Too small feed wires could cause this. If the wires feeding the refrigerating unit becomes warm, it is an indication that they are too small and should be replaced with larger wires
		A shortage of oil	Add oil if possible; if this is not possible, the unit must be replaced. A shortage of refrigerant will cause a shortage of oil in the crankcase of the compressor
	No refrigeration after starting up after a long shutdown or on delivery	Generally, during a long shutdown, an amount of liquid refrigerant will get into the crankcase of the compressor. When this happens, the compressor operation will cause no noticeable refrigeration effect until the entire liquid refrigerant has evaporated from the crankcase.	Allow the compressor to operate until its internal heat drivers the liquid refrigerant from the crankcase. Under some conditions, this may take as long as 24 hours. This time can be shortened by turning an electric heater on the compressor and raising the compressor temperature, not exceeding 110 degrees F.
	Compressor is noisy	Mountings have become worn or deteriorated. The walls against which the unit is placed may be of an extremely hard surface and may resound and amplify the slight noise from the compressor into the room	Replace the rubber mountings. Place a piece of sound-absorbing material on the wall against which the unit is placed, or move the unit to a new location.
		Shortage of oil and/or refrigerant	Add oil and refrigerant if possible. If it is impossible, the unit must be replaced.
		The sealed unit mechanism has become worn	Replace the unit
	After each defrosting there is a long on cycle before refrigeration is again normal	Slight shortage of refrigerant	Add refrigerant if possible; if not, replace the unit
		Condenser is dirty	Clean the condenser
		Thermostatic switch bulb is loose	Secure the bulb in place
		There is a restriction between the receiver or condenser and/or the evaporator	Attempt to remove the restriction by jarring with a plastic hammer or by heating the possible points of restriction to about 110 degrees F. If this does not correct the trouble, the unit must be replaced or brought to the shop for repairs

APPENDIX III

MATH TABLES

CONVERSIONS, EQUIVALENTS AND USEFUL FORMULAS

TABLE A

EQUIVALENTS

1 inch = 25 millimeters	1 ounce = 30 grams
1 foot = 0.3 meter	16 ounces = 1 pound
1 yard = 0.9 meter	1 pound = 450 grams
	1 liter = 1 quart (lq)
	1 teaspoon = 5 ml
	1 tablespoon = 15 ml
1 square inch= 6.5 sq. centimeters	1 cup = 250 ml
1 square foot= 0.09 square meter	4 cups = 1 quart
1 square yard= 0.8 square meter	1 gram = 0.035 ounces (avdp)
	1 kilogram = 2.2 pounds (avdp)
	1 ounce (avdp)= 28 grams
	1 pound (avdp)= 0.45 kilogram
1 cubic inch= 16 cubic centimeters	
1 cubic foot= 0.03 cubic meter	
1 cubic yard= 0.8 cubic meter	1 pound per square inch =
	0.07 kilograms per square centimeter
1 mile = 1.6 kilometers	1 kilogram per square centimeter =
1 kilometer = 0.6 mile	14.2 pounds per square inch
1 inch = 2.5 cm	
1 millimeter = 0.04 inch	
1 cubic centimeter = 0.06 cubic inch	1 Kilowatt= 1.3 horsepower
	1 horsepower = 0.75 kilowatt
1 meter = 3.3 feet	
1 meter = 1.1 yards	
1 square meter = 11 square feet	
1 square meter = 1.2 square yards	
1 cubic meter = 35 cubic feet	
1 cubic meter = 1.3 cubic yards	
1 cubic meter = 250 gallons	
1 quart (lq.)= 1 liter	
1 gallon= 0.004 cubic meter	

TABLE B

CONVERSION OF ENGLISH MEASURE TO METRIC/ENGLISH MEASURE

MULTIPLY	BY	TO OBTAIN
Cubic feet	2.832×10^{6}	Cubic cms
Cubic feet	1728	cubic inches
Cubic feet	0.02832	cubic meters
Cubic feet	0.03704	cubic yards
Cubic feet	7.481	gallons
Cubic feet	28.32	liters
Cubic feet	59.84	pints (liq)
Cubic feet	29.92	quarts (liq)
Cubic inches	16.39	cubic centimeters
Cubic inches	5.787×10^{-4}	cubic feet
Cubic inches	1.639×10^{-5}	cubic meters
Cubic inches	2.143×10^{-5}	cubic yards
Cubic inches	4.329×10^{-2}	gallons
Cubic inches	1.639×10^{-2}	liters
Cubic inches	0.03463	pints (liq)
Cubic inches	0.01732	quarts (liq)
Cubic yards	7.636×10^{5}	cubic centimeters
Cubic yards	27	cubic feet
Cubic yards	46.656	cubic inches
Cubic yards	0.7646	cubic meters
Cubic yards	202.0	gallons
Cubic yards	764.6	liters
Cubic yards	1616	pints (liq)
Cubic yards	807.9	quarts (liq)
Feet	30.48	centimeters
Feet	0.3048	meters
Feet	.36	yards
Feet	1/3	yards
Feet of water	0.02950	atmosphere
Feet of water	0.8826	inches of mercury
Feet of water	304.8	kgs per sq meter
Feet of water	62.43	pounds per sq ft
Feet of water	0.4335	pounds per sq inch
Gallons	3785	cubic centimeters
Gallons	0.1337	cubic feet
Gallons	231	cubic inches
Gallons	3.785×10^{-3}	cubic meters
Gallons	4.951×10^{-3}	cubic yards
Gallons	3.785	liters

TABLE B (Continued)

CONVERSION OF ENGLISH MEASURE TO METRIC/ENGLISH MEASURE

MULTIPLY	BY	TO OBTAIN
Inches	2.540	centimeters
Inches	10^4	mils
Inches	.03	yards
Inches of mercury	0.03342	atmosphere
Inches of mercury	1.133	feet of water
Inches of mercury	345.3	kgs per sq meter
Inches of mercury	70.73	pounds per sq ft
Inches of mercury	0.4912	pounds per sq inch
Inches of water	0.002458	atmospheres
Inches of water	0.07355	inches of mercury
Inches of water	25.40	kgs per sq meter
Inches of water	0.5781	ounces per sq in
Inches of water	5.204	pounds per sq ft
Inches of water	0.03613	pounds per sq inch
Ounces	8	drams
Ounces	437.5	grains
Ounces	28.35	grams
Ounces	0.0625	pounds
Ounces (fluid)	1.805	cubic inches
Ounces (fluid)	0.02957	liters
Pounds	7000	grams
Pounds	453.6	grams
Pounds	16	ounces
Pounds	32.17	poundals
Pounds	0.8229	pounds (av)
Pounds of water	0.01602	cubic feet
Pounds of water	27.68	cubic inches
Pounds of water	0.1198	gallons

TABLE C

CONVERSION OF METRIC/ENGLISH TO ENGLISH MEASURE

MULTIPLY	BY	TO OBTAIN
Centiliters	0.01	Liters
Centimeters	0.3937	inches
Centimeters	0.01	meters
Centimeters	393.7	mils
Centimeters	10	millimeters
Cubic centimeters	3.531×10^{-3}	cubic feet
Cubic centimeters	6.102×10^{-2}	cubic inches
Cubic centimeters	10-6	cubic meters
Cubic centimeters	1.306×10^{-6}	cubic yards
Cubic centimeters	2.642×10^{-4}	gallons
Cubic	10-2	liters
centimeters Cubic	2.113×10^{-3}	pints (liq)
centimeters	1.057×10^{-3}	quarts (liq)
Cubic centimeters	10^{4}	cubic centimeters
Cubic meters	35.31	cubic feet
Cubic meters	81.023	cubic inches
Cubic meters	1.303	cubic yards
Cubic meters	264.2	gallons
Cubic meters	10^{2}	liters
Cubic meters	2113	pints (liq)
Cubic meters	1057	quarts (liq)
Cubic meters	10^{2}	grams
Kilograms	70.93	poundals
Kilograms	2.2046	pounds
Kilograms	1.102×10^{-2}	tons (short)
Kilograms	3281	feet
Kilometers	10^{7}	meters
Kilometers	1093.6	yards
Kilometers	10^{2}	cubic centimeters
Liters	0.03531	cubic feet
Liters	61.02	cubic inches
Liters	10^{3}	cubic meters
Liters	1.308×10^{-2}	cubic yards
Liters	0.2642	gallons
Liters	2.113	pints (liq)
Liters	1.057	quarts (liq)
Liters	100	centimeters
Meters	3.2808	feet
Meters	39.37	inches
Meters	10^{-3}	kilometers
Meters	10^{3}	millimeters
Meters	1.0936	yards
Meters	25	inches
Millimeters		

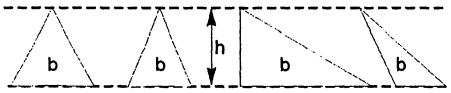
TABLE D

USEFUL FORMULAS

Triangle:

$$\text{Area} = \frac{b \times h}{2}$$

$$\text{Volume} = \frac{b \times h}{2} \times \text{length}$$



TRIANGLES UTB10246

Square/Rectangle:

$$\text{Area} = b \times b$$

$$\text{Volume} = b \times b \times b$$

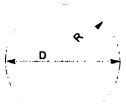
$$\text{Perimeter} = 2b + 2b$$

SQUARE RECTANGLE
UTB10247

Circle:

$$\text{Area} = \pi \times R^2$$

$$\text{Volume} = \pi \times R^2 \times \text{length}$$

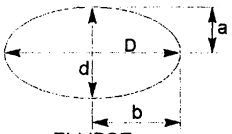


CIRCLE UTB10248

Ellipse:

$$\text{Area} = \frac{\pi \times D \times d}{4}$$

$$\text{Volume} = \frac{\pi \times D \times d}{4} \times \text{length}$$



ELLIPSE UTB10249

Circular cone:

$$\text{Lateral area} = s \times \pi \times R$$

$$\text{Volume} = \frac{\pi \times R^2 \times h}{3}$$

RIGHT CIRCULAR CONE
UTB10250

APPENDIX IV

ANSWER KEY

CHAPTER 1 — BOILERS

STEAM GENERATION THEORY

Q1. Temperature increases and the volume expands.

Q2. Heat intensity.

Q3. Temperature of steam and boiling water.

BOILER DESIGN REQUIREMENTS

Q4. 1) Safe to operate; 2) Able to generate steam at desired rate and pressure; and 3) Economical.

Q5. American Society of Mechanical Engineers (ASME).

TYPES OF BOILERS

Q6. Water-tube and fire-tube.

Q7. 1) Scotch Marine; 2) Vertical-tube; 3) Horizontal return; and 4) Firebox.

Q8. They require no setting.

BOILER FITTINGS AND ACCESSORIES

Q9. Lowest point of the boiler spaces.

Q10. Annually.

Q11. At the steam drum above the water level and 6 inches below the water level.

Q12. 1) Float operated; 2) Float and mercury switch; and 3) Electrode probe.

Q13. Three.

Q14. Safety valve.

Q15. Backup to main steam stop.

AUTOMATIC CONTROLS

Q16. Pressure regulating.

Q17. Combustion control.

Q18. The air damper.

Q19. Manual reset.

INSTRUMENTS AND METERS

Q20. Indicating rate and indicating the total.

Q21. Pressure difference producing the flow.

BOILER WATER TREATMENT AND CLEANING

Q22. Precipitates of hardness.

Q23. External and internal.

Q24. 30 ppm and 60 ppm.

Q25. Causticity exists.

Q26. 70°F.

CLEANING BOILERS FIRESIDES AND WATERSIDES

Q27. 1) Wire brush and scraper; 2) Hot-water washing; 3) Wet-steam lancing; and 4) Sweating.

Q28. 70 to 150 psig.

Q29. Pitting and general corrosion.

Q30. 1) Hydrochloric acid; 2) Phosphoric acid; 3) Sulfamic acid; 4) Citric acid; and *4)* Sulfuric acid.

Q31. Circulation and fill and soak.

CHAPTER 2 — BOILER MAINTENANCE

MAINTENANCE OF AUXILIARY EQUIPMENT

Q1. Low water.

Q2. Plug valve opening on gauge glass.

Q3. 1) Controlling high water; 2) Removing sludge and sediment; 3) Controlling chemical concentrations; and 4) Dumping a boiler for cleaning or inspection.

Q4. Tightness of all the parts and strength of the drum.

BOILER TUBES

Q5. 1) Name or trademark of manufacturer; 2) Heat number; 3) Class letter; 4) Specification number; and 5) Outside diameter, wall thickness, and length.

Q6. Arc welding equipment.

Q7. 3/16" to 5/16".

Q8. 1/8" to 3/16".

Q9. Drill a hole in the tube.

REPAIRING BOILER REFRACTORIES

Q10. Escape of steam created from moisture in the brick.

Q11. 2900° to 3000°F.

Q12. Improperly sealed doors.

BOILER OPERATIQNS

Q13. To ensure equipment and the boiler are in sound operating condition and functioning properly.

Q14. Line-up boiler systems.

Q15. Open all drain valves between the boiler, the header, and the two stop valves.

Q16. 1) Maintain proper water level and 2) present loss of ignition.

Q17. 150°F.

Q18. 25 psig.

Q19. Record continuous data of plant performance.

SAFETY

Q20. Hard hat, goggles, and safety toed shoes.

Q21. Green.

Q22. Safety valve.

Q23. Keys can be controlled easier than combination locks.

CHAPTER 3 — STEAM DISTRIBUTION SYSTEMS

EXTERIOR STEAM DISTRIBUTION SYSTEMS

Q1. Underground and aboveground.

Q2. Their high cost of installation.

Q3. High cost of maintenance.

INTERIOR STEAM DISTRIBUTION SYSTEMS

Q4. Hydrostatic head.

Q5. Inhibits emission of heat from the heating system.

Q6. A return trap system has a gravity return and a condensate pump system has a forced return.

Q7. Withdraws air and water from the system, separates them, expels the air, and pumps the water back to the boiler.

STEAM DISTRIBUTION SYSTEM COMPONENTS

Q8. Fin-tube and cast iron.

Q9. 10°F or lower than that of the water.

Q10. Upright or standard, and inverted.

Q11. The bellows develops holes.

Q12. Emvar and copper.

Q13. Pyrometric crayon test.

Q14. Storage and instantaneous.

Q15. Temperature regulator.

Q16. 1) Slip, 2) bellows, 3) swing, 4) expansion loop, and 5) ball.

Q17. Annually.

CHAPTER 4 — HEATING SYSTEMS

PRINCIPLES OF HEATING

Q1. Combustion, friction, and chemical action or resistance to flow of electricity.

Q2. Temperature and pressure.

Q3. Heat intensity in degrees Fahrenheit or Celsius.

Q4. 27.8°C.

Q5.. Conduction, convection, and radiation.

COMBUSTIBLE FUELS

Q6. Natural gas, manufactured gas, and liquefied petroleum gas.

Q7. Hydrogen and carbon (hydrocarbons).

WARM-AIR HEATING EQUIPMENT

Q8. Suspended vertical discharge, suspended horizontal discharge, and floor mounted.

Q9. In Kw.

Q10. Safety.

Q11. Condensation.

Q12. Atmospheric vaporizing burners.

Q13. Fuel level control valve.

Q14. Draft regulator.

WARM-AIR HEATING SYSTEMS

Q15. Rate of delivery and temperature of the air delivered.

Q16. Vertical counter-flow, up-flow, highboy, lowboy, and horizontal unit.

Q17. Thermocouple control relay.

Q18. The limit control.

Q19. Burner compartment combustion, radiating compartment, and blower compartment.

Q20. The thermostat.

Q21. Spiral-bimetallic and mercury bulb.

Q22. 75 to 150 psi.

Q23. Manufacturer's instruction manual.

Q24. Flue gas analyzer.

DOMESTIC HOT-WATER HEATING AND HOT-WATER BOILERS

Q25. Increase the pressure of the boiler to operate the valve monthly.

Q26. "Sailswitch."

HOT-WATER HEATING DISTRIBUTION SYSTEM

Q27. It is difficult to get enough circulation to avoid large temperature drops from one end of the system to the other.

Q28. Pneumatic compression tank.

Q29. Circulation of water, thus reducing heating capacity.

HIGH-TEMPERATURE HOT WATER SYSTEMS

Q30. 350°F to 450°F.

Q31. Hot-water boilers or generators and cascade or direct contact heaters.

Q32. 20 to 40 ppm.

Q33. True.

CHAPTER 5 — GALLEY AND LAUNDRY EQUIPMENT

GALLEY EQUIPMENT

Q1. Medical Department.

Q2. Self-contained.

Q3. True.

Q4. As needed.

Q5. 5°F

Q6. 138°F to 145°F.

Q7. Small particles could become embedded in food.

Q8. Blue.

Q9. Weekly.

Q10. Concrete or brick.

Q11. Quarterly.

LAUNDRY EQUIPMENT

Q12. 88 minutes.

Q13. Five.

Q14. 25 psi.

Q15. 30 psi.

Q16. Every 2 months.

Q17. True.

Q18. Ensure the proper power is being connected.

Q19. 4 square feet.

Q20. True.

Q21. 5 minutes.

Q22. Manufacturer's instructions.

Q23. Blower rotor blades.

Q24. Fill, agitate, drain, and spin.

Q25. Main drive motor.

Q26. Electric and gas.

CHAPTER 6 — REFRIGERATION

HEAT AND REFRIGERATION PRINCIPLES

Q1. False.

Q2. A quantity of heat required to change the temperature of 1 pound of any substance 1°F compared to water.

Q3. Sensible heat is the increase of temperature, and latent heat is the change of state.

Q4.. 12.7 psia.

Q5. Decreases its volume in proportion to the increase of pressure.

Q6. Condense into a liquid.

MECHANICAL REFRIGERATION SYSTEMS

Q7. Reciprocating, rotary, and centrifugal.

Q8. The external is positioned on the outside of the crankcase.

Q9. The inaccessibility or repair and low capacity.

Q10. Dry or flooded.

Q11. Refrigerators and window air conditioners.

Q12. To determine the presence and amount of vapor in the refrigerant.

REFRIGERANTS

Q13. Chloroflorocarbons and hydrochloroflorocarbons.

Q14. Reduced efficiency, mechanical problems, and dangerous conditions.

Q15. CFCs and HCFCs.

Q16. R-134a.

REFRIGERANT SAFETY

Q17. False.

Q18. Anytime a refrigerant is discharged.

Q19. To avoid confusion.

REFRIGERATION EQUIPMENT

Q20. Remote equipment has a condenser at a remote location from the main unit.

Q21. Between 30°F and 45°F.

Q22. A unit cooler type.

Q23. Ease of assembly and ease of relocation.

Q24. Single door and multi-door.

Q25. Hot gas and/or electric heater.

Q26. Heat exchanger.

Q27. The type of evaporator installed.

INSTALLATION OF REFRIGERATION EQUIPMENT

Q28. Hydrochloric acid.

Q29. To permit unrestricted airflow.

Q30. Vibration strain.

Q31. A neutral atmosphere within the tube or pipe.

Q32. Ten feet.

Q33. True.

MAINTENANCE, SERVICE, AND REPAIR OF REFRIGERATION EQUIPMENT

Q34. Manifold gauge set and vacuum pump.

Q35. To get its pressure lower than the storage cylinder.

Q36. To remove moisture and air from the system.

Q37. Until a deep vacuum has been obtained.

Q38. Low-side charging.

Q39. Halide, electronic, or soap and water.

Q40. Condenser/receiver.

Q41. Vapor and liquid.

Q42. Single or multiple pass method.

MAINTENANCE OF COMPRESSORS

Q43. Shaft bellows seals.

Q44. Weak refrigerant charge.

Q45. Leaks, high temperatures, or vibrations.

MAINTENANCE OF MOTORS

Q46. Mechanical and electrical.

Q47. After every repair or replacement.

Q48. A dehydrator.

Q49. 35°F or below.

Q50. Across the component.

Q51. Ohmmeter on lowest setting.

Q52. A short.

Q53. True.

LOGS

Q54. True.

Q55. False.

CHAPTER 7 — AIR CONDITIONING

PRINCIPLES OF AIR CONDITIONING

Q1. Effective temperature.

Q2. True.

Q3. Humidity.

Q4. Sling psychrometer.

Q5. True.

Q6. Air becomes saturated.

Q7. Permanent and throwaway types.

Q8. Velocity of the air.

AIR-CONDITIONING SYSTEMS

Q9. Window-mounted and floor-mounted units.

Q10. User.

Q11. Package units.

Q12. Heat pumps.

Q13. Condenser to the evaporator.

Q14. Accumulate frost or ice.

Q15. Balance point.

Q16. Flooded shell and tube and dry-expansion.

Q17. Thermostatic.

Q18. Easy to make.

Q19. Mechanically or chemically.

Q20. Annually.

MAJOR SYSTEM COMPONENTS AND CONTROLS

Q21. By the method of moving air through the tower.

Q22. False.

Q23. Induced draft.

Q24. Counter flow or cross-flow.

Q25. Parallel flow.

Q26. Redwood.

Q27. 2 gallons.

Q28. Domestic refrigerators and small water coolers.

Q29. Belt drive and crankshaft seal.

Q30. Thermostat.

Q31. Humidistat.

Q32. Motor overload protector.

AUTOMOTIVE AIR CONDITIONING

Q33. According to the pressure exerted on the liquid or vapor.

Q34. Two-cylinder reciprocating, swash plate, and scotch yoke.

Q35. Reciprocating motion.

Q36. True.

Q37. VIR (valves-in-receiver).

Q38. True.

Q39. Know the system.

Q40. As a oily residue at the point of leakage.

Q41. Damaged or missing O-rings.

Q42. Liquid.

Q43. The suction accumulator/drier.

Q44. Universal type.

Q45. Environmental Protection Agency.

DUCTWORK

Q46. Conditioned air ducts, recirculating air ducts, and fresh air ducts.

Q47. Single return, multiple return, and a combination of the systems.

Q48. True.

Q49. Butterfly, multiple blade, and split damper.

Q50. Measure the "free" grille area.

APPENDIX V

REFERENCES USED TO DEVELOP THE TRAMAN

NOTE: Although the following references were current when this TRAMAN was published, their continued currency cannot be assured. Therefore, you need to be sure that you are studying the latest revision.

Air *Handling Units,* NFGS – 15720, Department of the Navy, Naval Facilities Engineering Command, Alexandria, VA, 1995.

Althouse, Andrew D., Alfred F. Bracciano, and Carl H. Turnquist, Modern *Refrigeration and Air Conditioning,* Goodheart-Willcox Co., Inc., 1992.

Boiler Care Handbook, Cleaver-Brooks Division of Aqua-Chem Inc., Milwaukee, WI, 1985.

Central Refrigeration Equipment for Air Conditioning, NFGS – 15601, Department of the Navy, Naval Facilities Engineering Command, Alexandria, VA, 1997.

Cleaver-Brooks Operation, Service and Parts Manual, Nos. 750-90 and 750-91, Cleaver-Brooks Division of Aqua-Chem Inc., Milwaukee, WI, 1983.

Extractor M3OEXTR1AE User Manual, Pellerin Milnor Corp., Kenner, LA, 1987.

Food Service Equipment, MIL-HDBK - 1119, Department of the Navy, Naval Facilities Engineering Command, Alexandria, VA., 1991.

Heating, Ventilating, Air Conditioning, and Dehumidifying Systems, NAVFAC Design Manual 3.3, Department of the Navy, Naval Facilities Engineering Command, Alexandria VA, 1987.

Heating, Ventilating, Air Conditioning, and Sheet Metal Work, TM 5-745, Department of the Army, Washington, DC, 1968.

Jazwin, Richard, *The Four R's, Recovery, Recycling, Reclaiming, and Regulation,* Business News Publishing Co., Troy, MI, 1992.

Laundry Dryer, 50 Lb., Model L34SMS30, Owner's Manual, Cissell Manufacturing Company, Louisville, KY, 1990.

Maintenance and Operation of Heating Systems, MIL-HDBK 1114/2, Naval Facilities Engineering Command, Alexandria, VA, 1964.

Navy Electricity and Electronics Training Series (NEETS), *Introduction to Circuit Protection, Control, and Measurement,* Module 3, NAVEDTRA B72-03-00-93, Naval Education, and Training and Professional Development Technology Center, Pensacola, FL, 1993.

Open End Washer MT36OEW1DE Technical Manual, Pellerin Milnor Corp., Kenner, LA, 1987.

Steingness, Frederick M., *Low-Pressure Boilers,* American Technical Publishers, Inc., Alsip, IL, 1981.

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